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Economic Impact of Malaria in Africa

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by

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Preface

This report is the product of a four-month study prepared for the Africa Bureau and the Office of Health of the Bureau of Science and Technology of the U. S. Agency for International Development. We wish to acknowledge the contribution of time, data, opinion, and critical comment of the following persons and organizations, none of whom should be held responsible for the quality of this report: Andrew Arata, Martine Audibert, Victor Barbiero, David Bell, Agnes Brinkmann, Allison Brucker, Carlos Campbell, Dennis Carroll, Richard Cobb, Brian Doberstyn, Steven Forsythe, Pradeep Goel, Norman Gratz, Barbara Guynn, Jeff Hammer, Kathleen Henry, Eckhard Kleinau, Joan LaRosa, Robert Lennox, Bernhard Liese, Theo Lippeveld, Dennis Long, Michelle MacKenzie, Anne Martin, Jeffrey Mecaskey, Gary Merritt, Charles Myers, Ellen Nayeri, Athanase Ntampuhwe, Celestin Nyabonziza, John Paul, Michael Reich, Gabriel Schmunis, James Shepperd, Andrew Spielman, Awash Teklehaimanot, Carol Vlassoff, FEWS Project, USAID Missions in Africa, WASH Project.

We are particularly grateful to Peggy Sullivan of the Vector Biology and Control Project, who has made many valuable contributions and given unfailing support to this effort. As a byproduct of this study, we have identified a number of documents not previously listed in the VBC Information Center in Arlington, VA. We will be providing copies or sources for any items they need. Requests for assistance in obtaining any needed documents should be directed to the VBC Information Center.

All views expressed in this report are those of the authors; inclusion in this report does not constitute endorsement of any of these views on the part of the sponsors of the research.

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Executive Summary

Malaria is probably the foremost health problem in Africa. Comparative disease data are limited, but malaria consistently ranks highest as a cause of illness. In Rwanda, for example, malaria was by far the greatest cause of both morbidity and mortality in 1989. Fever, which is predominantly due to malaria, was the largest single cause of ambulatory illness in Chad in 1988. In Burkina Faso, malaria was the greatest cause of visits to health facilities. A classic study in Ghana, which used 1975 data, found that malaria caused the largest loss of potential days of life.

Moreover, the number of cases and deaths from malaria have risen steadily during the past decade in a number of African countries. In three countries for which we found long-term data, malaria incidence increased by seven percent (Zambia), 10 percent (Togo) and 21 percent (in Rwanda) every year for the past 10 years. Experts fear that the conditions that apparently contributed to this increase are likely to continue in the short run. These factors include population migration, growing resistance to antimalarial drugs such as chloroquine, limited resources for malaria treatment and control, and irrigation and other development activities that create mosquito breeding sites. Thus, the burden of malaria in 1995 is likely to be two to three times its level in the late 1980s.

Despite the importance of the disease, there is little research on its economic impact. An extensive literature search identified only one empirical paper on economic effects in Africa, and that study suffered from an insensitive measure of malaria.

This study focuses primarily on two categories of economic impact: its so-called direct costs, which are costs of treatment and control programs, and its indirect costs, which are the value of lost income due to morbidity and premature mortality. Direct costs include the cost of drugs and patient transportation. The impact of absenteeism from worksites and schools because of malaria are among the indirect costs. A final category of impact would be intangible effects, representing the discomfort of being ill or of knowing that a loved one is ill. This category has not been included due to lack of data.

Data are not available to assess the economic impact of malaria in as a whole Africa. Therefore, this study consisted of four national or sub-national case studies based on published and unpublished data. The sites were chosen based on availability of data and interesting methodological elements. One case -- Rwanda -- examines a national situation where there are good epidemiological and cost data from health facilities. The case in Burkina Faso derives from household surveys on production and illness. Epidemiological data from public sources and expenditure figures from individual surveys are used to analyze malaria's impact in a province in Chad. The case of Brazzaville, Republic of the Congo, depends almost entirely on published literature and examines an urban industrialized economy, rather than a rural one. The cases, then, represent the range of types of malaria and availability of data in Africa.

Figure A examines cost per case based on current data (1984 to 1989, depending on the site) and makes projections to 1995. As a standard of comparison, the daily per capita output, the value of all goods and services produced in an economy, averaged $0.82 per day in Africa in 1987. The average cost per case for sub-Saharan Africa of $9.68 represents about 12 days of output. By 1995, the projected cost per case is 23 days of output (valued then at $0.77 per day). The direct cost of $3.40 per case is equal to the entire annual public sector health expenditure in many African countries. That is, treatment of one case of malaria exhausts a person's entire share of his government's health resources.

Cost per capita per year is shown in Figure B. For sub-Saharan Africa as a whole, we project malaria cost per capita almost doubling as both incidence and cost per case increase. Overall, we project an annual cost of $3.16 per person. The current burden of malaria in sub-Saharan Africa is equivalent to a loss of 2.1 days of output for every person. By 1995, it will probably be 4.1 days.

By current estimates, malaria in sub-Saharan Africa costs about $800 million per year. This figure is projected to rise to over $1.8 billion by 1995. In contrast, the estimated A.I.D. health budget for sub-Saharan Africa in fiscal 1991 is $63 million.

Figure C shows malaria cost as percent of output, both current and projected. The burden is greatest in the two sites that are entirely rural, Solenzo and Mayo-Kebbi, due to the combination of frequent and costly cases combined with low output. For sub-Saharan Africa overall, the current cost of malaria averages 0.6 percent of GDP and is projected to double to 1.1 percent by 1995. By comparison, the entire budget of the Ministry of Health for one African country, Rwanda, was only 0.9 percent in 1988. Thus, the total direct and indirect costs for this one disease outstrip the public resources available for all diseases.

Effective malaria control measures would have a substantial payoff. Simply averting the growth in cost of malaria as a share of output would save 0.5 percentage points of GDP. With no further increase, the burden would be maintained at 0.6 percent of GDP, rather than 1.1 percent, as forecast for 1995. If the burden of malaria could be cut by reducing incidence, severity, or treatment costs, a greater share of GDP would be saved. If the current burden were reduced by somewhat more than a half, the future economic burden of malaria could be a full percentage point less than the 1.1 percent of GDP projected for 1995 for sub-Saharan Africa.

Studies of economic costs of illness would allow donor and host country officials to demonstrate the value of selected control strategies through cost-benefit analyses. For example, in a Gambian study, use of insecticide-impregnated bed nets reduced clinical attacks of malaria in children by 63 percent compared to use of nets with no insecticide. If children were half of the population, the per capita cost of this control measure would be $0.62 per year. Assuming the projected economic benefits were 63 percent of the current average costs of malaria in Africa, the per capita economic benefits would be $1.08 now and $1.99 in 1995. Thus, the benefits would be two to three times the costs.

For an average area in sub-Saharan Africa, an expenditure of up to $0.20 per capita is economically justified if it achieves only a 10 percent reduction in the cost of malaria. Studies of economic impact could be combined with operations research studies to evaluate the costs and effectiveness of various malaria control measures, including laboratory services, improved supervision, community pharmacies, and training of health workers.

This study was undertaken to provide a first exploration of prior attempts at assessment of economic impact of malaria and the outline of a methodology for future study. The findings presented here are all based on existing data from published and unpublished documents and research studies. Clearly, a complete understanding of the mechanism and magnitude of malaria's economic impact will require further prospective research. The estimates of malaria's impact in Africa presented here develop and test a methodology, point the way to several avenues of new research, and can inform policy decisions in the interim.

Fig. A Malaria Cost per Case by Site

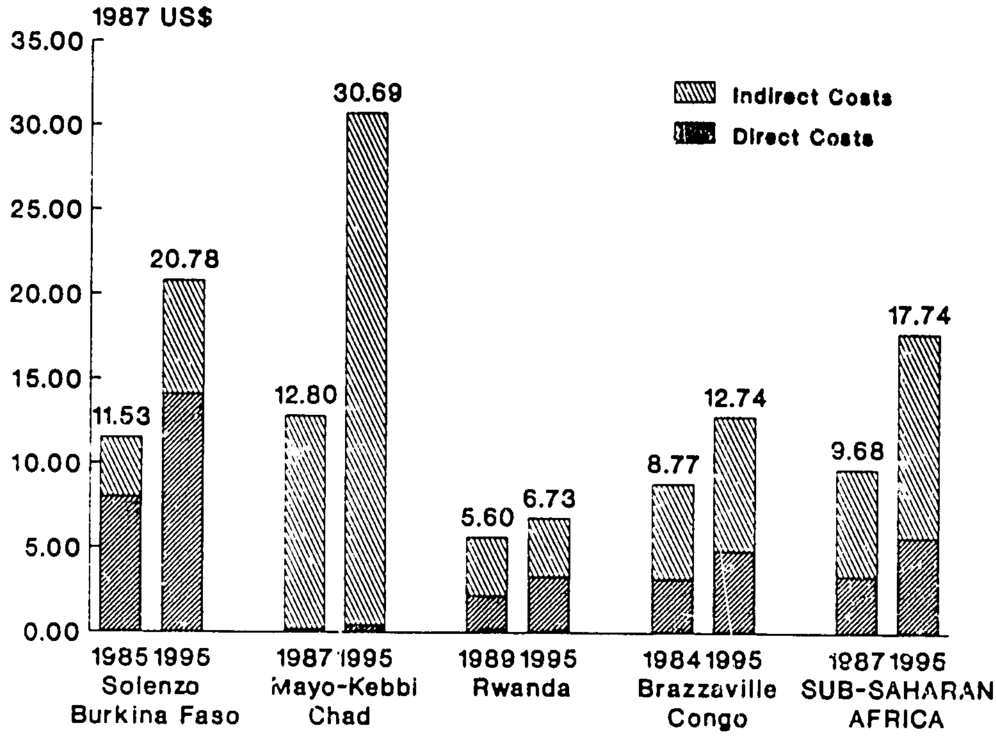


Fig. B Malaria Cost per Capita by Site

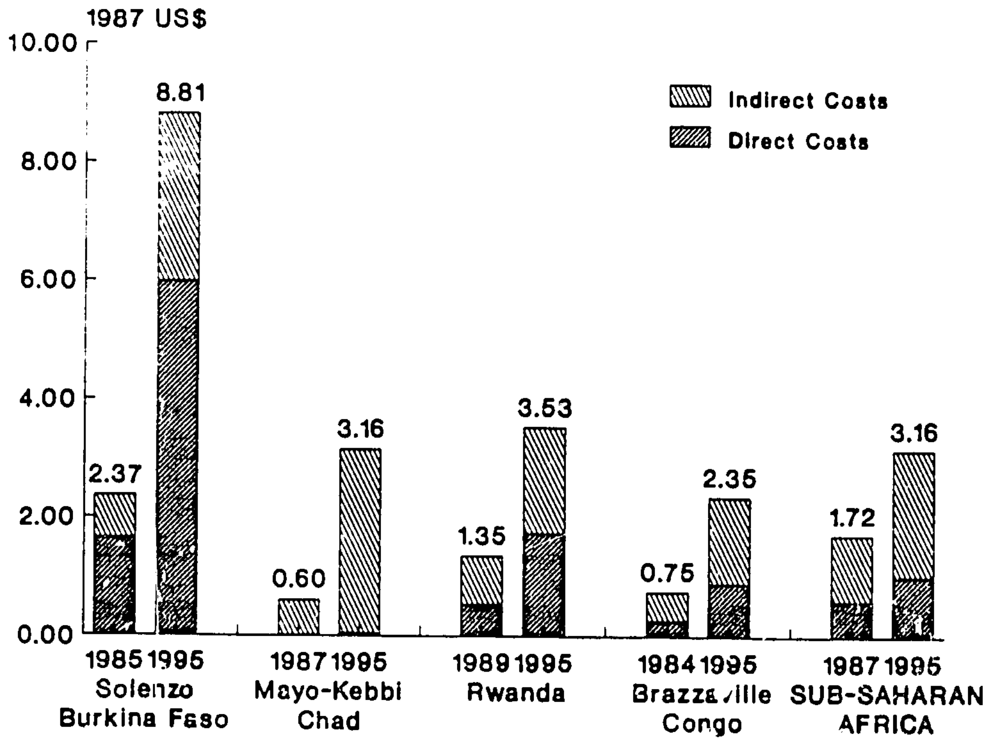
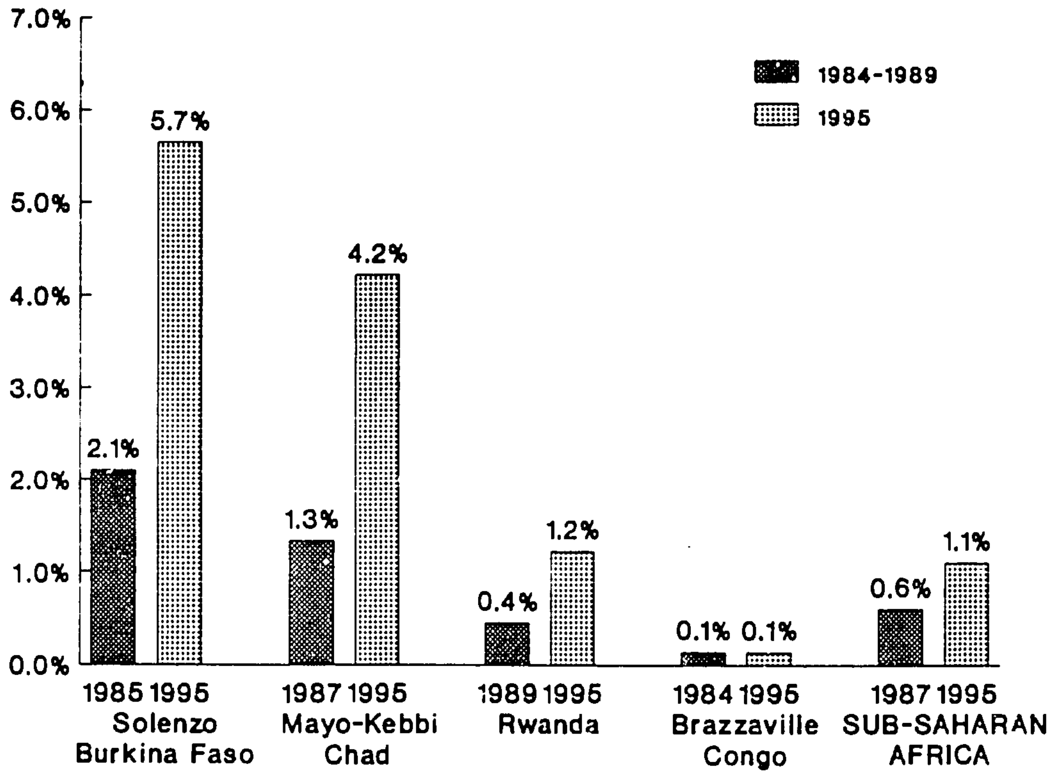


Fig. C Malaria Cost as % of Output by Site



Introduction

Many African countries consider malaria to be their major health problem. Drug resistance, changing disease epidemiology, migration, urbanization, and competing priorities from other health needs have all contributed to the explosion of this problem.

Economic stagnation and decline has been one of Africa's major policy concerns. According to the World Bank (1989a), from 1980-87 per capita GNP declined by 2.8 percent in sub-Saharan Africa while it grew by four percent among all low-income economies.

Given the urgent economic problems facing the area, continued expenditure of public resources on the control and reduction of malaria in the region demands an examination of the impact of this disease. Malaria's significance as a public health problem is undeniable. However, its significance as an inhibitor of economic growth and development has yet to be explicitly measured.

This study was undertaken to provide a first exploration of prior attempts to assess the economic impact of malaria and the outline of a methodology for future study. The findings presented here are all based on existing data from published and unpublished documents and research studies. Clearly, a complete understanding of the mechanism and magnitude of malaria's economic impact will require further prospective research. The estimates of malaria and its impact in Africa presented here can point the way to several avenues of new research and inform policy decisions in the interim.

This study begins by reviewing previous studies of the economic effects of malaria (Chapter 2) and describing the magnitude of the disease's impact on health in sub-Saharan Africa (Chapter 3). Chapter 4 presents the background, methodology and findings of case studies of the economic impact of malaria in four African sites, based on published and unpublished literature. The results of these case studies are extrapolated to all of sub-Saharan Africa in Chapter 5. Finally, we present our conclusions and make recommendations for using this methodology in the field to assess the costs, benefits and advisability of malaria control measures (Chapter 6). Comprehensive bibliographies and more detailed explanations of the methodology used are provided in the annexes.

2. Measuring the Economic Effects of Malaria

Expenditures on prevention and treatment

The economic impact of malaria in Africa falls into three broad categories (Table 1). First are the direct effects on individual, household and national budgets brought about by expenditure on the treatment and prevention of malaria. Costs of proposed control programs are regularly estimated, but household expenditures on prevention and treatment of malaria is less often assessed for populations. More often the direct costs of malaria are expressed as proportions of health budgets or of hospital admissions. In all, we located 48 documents that included an estimation of direct costs as part of a discussion of the impact of malaria in locations throughout the world. A list of these documents is found in Annex B.1.

Table 1 Components of the Economic Impact of Malaria

Direct Costs	Treatment Prevention	Expenditures of households and governments
Indirect Costs	Mortality Morbidity Debility Treatment Time	Economic output (e.g. crop yields)
Intangible Effects	Health status	Quality of life

Effects on output

The second category comprises the indirect effects of malaria mortality, morbidity and debility on individual, household and national productivity. The number of working days are diminished because of malaria-related absenteeism and mortality. This reduction in the effective quantity of labor inputs can have substantial effects on the quantity of output. This effect can result not only from morbidity in the active labor force but also from time lost in caring for children, who are more frequently and seriously affected.

Previous studies of the economic impact of malaria have focused either on the direct or indirect effects on budgets and productivity. Several from South Asia (Sinton 1938, Khan 1966, Malik 1966) have assigned a cost per case and applied it to an estimated total number of cases. Bhombore (1952) compared output of Indian villages with varying malaria incidence to assess the effect of malaria on family budgets and productivity.

Assessments in Africa, for the most part, date from the colonial period and refer to plantation or industrial situations. More recently, Gazin et al. (1988b) report that 17 percent of workers in an enterprise in Bobo Dioulasso claimed to have missed an average of 3.5 days of work in the previous rainy season because of malaria. Similar estimates of the time lost to rural agricultural families are noticeably lacking. Altogether, we examined 55 documents that directly addressed the estimation of these effects on the quantity of labor and its role in production. A list of these documents is found in Annex B.2.

Malaria-related debility may also affect the quantity of output if it reduces the work capacity of individuals. Pehrson et al. (1984) report no difference in working capacity between Liberian industrial workers taking regular malaria chemoprophylaxis (a surrogate for no malaria) and those unprotected. The same team (Brohult et al. 1981) reports a similar lack of difference in working capacity between urban, protected populations and rural, unprotected populations in Liberia. However, malaria is known to relate closely to nutrition and anemia, two factors demonstrated to affect working capacity. A number of studies have addressed this effect for other diseases with results that, taken as a group, are ambiguous.

Reduced utilization of physical resources, primarily land, in malarious areas will also affect output quantity. Evidence of this effect from Swaziland (Packard 1984 and 1986) and from the Awash Valley of Ethiopia (Holly 1970) suggests that malarious areas are avoided, and that control of the disease can lead to increased productivity.

The quality of labor is affected by malaria morbidity both during acute attacks and as a result of the cumulative effects of ubiquitous illness on an individual and a society. Even though an acute attack may not be severe enough to prevent work, the debility may reduce the quality of the output. In addition, there is evidence that the risk of malaria may affect output quality through an influence on systems of production and decisions about crops. Stevens (1977) and Malenbaum (1973) both make this point theoretically. Conly (1975) demonstrated this effect among rural farmers in Paraguay, who shifted their work input under threat of malaria from tobacco and other lucrative cash crops to less labor-critical but also less valuable crops such as cassava. These crops would not be as susceptible to complete loss in the event of sickness.

Labor quality is also affected by malaria's impact on education. Absenteeism due to malaria was assessed at five days per child per year among primary school students in Accra (Colbourne 1955). Colbourne cites unpublished data of Wilson, also from Ghana, which estimate attacks among adolescent students at 0.4 per year, with about two days of absence per attack. More recently, Trape et al. (1987) determined the annual attack rate among rural schoolchildren in Congo to vary from 0.8 to 5.2, depending on age and type of survey. Almost all attacks were treated immediately and therefore were limited to one day. Nevill et al. (1988) report an estimated 0.8 episodes per student during a 12-week term in a Kenyan boarding school, but it is not clear that an episode represents a clinical attack. Three other studies describe the effect of malaria on education but do not report how the effect was estimated. Documents related to malaria's effect on the quality of labor are listed in Annex B.3.

An assessment of these indirect effects of malaria on production will be strongly influenced by seasonality in malaria morbidity and in the shadow wage rate of labor. Several authors have addressed this issue in regard to Africa, notably Mwabu (1988).

Assessment of the overall effects of malaria on productivity can focus on one of two levels. Microeconomic studies examine the effects of malaria on productivity using individual farms as the unit of analysis. Using this technique in Paraguay, Conly (1975) compared the crop yields of farms with low, moderate, and high rates of malaria. Audibert (1986) reported an examination of the effects of both malaria and schistosomiasis among rice farmers participating in a large-scale irrigation project in north Cameroon. This careful study shows no overall significant effect of malaria on production, although the effect is significant for certain seasons and areas. The general absence of an effect may arise from the fact that the study measured malaria only by parasite positivity at fixed times during the dry season, which is a period of low transmission. It did not assay clinical illness or parasitemia during periods of peak transmission. The effect of schistosomiasis was very significant, suggesting that a 4.9 percent increase in productivity would result from a 10 percent decrease in prevalence of schistosomiasis. Thus, Audibert's study confirms that illness, when properly measured, does reduce agricultural productivity.

Two recent microeconomic studies, by Castro and Mokate (1988) in Colombia and Nur and Mahran (1988) in Sudan, have examined the extent of labor substitutions that reduce the effect of malaria morbidity and debility on overall production but can cause significant dislocations of routine family activity. Neither study measures the residual reduction in productivity resulting from malaria. Soro (1990) estimates the annual number of adult work days lost in Ivory Coast to malaria at half a million (one day lost for every ten adults) but does not convert this to a loss in production. Microeconomic studies of the effect of malaria on communities are listed in Annex B.4.

Macroeconomic assessments use a country or region as the unit of analysis. Some of these studies use historical comparison before and after eradication. The benefits described for Greece (Livadas and Athanassatos 1963), Transvaal (Annecke 1950), and Ethiopia (Holly 1970) are but a few of the many marshalled to justify implementation and expansion of control efforts elsewhere. We have identified 29 documents that discuss the economic impact of malaria in general historical terms.

Other macroeconomic assessments derive from a cross-sectional comparison of highly malarious and less-malarious countries on a number of macroeconomic variables (Wernsdorfer and Wernsdorfer 1988, Malenbaum 1970). This method substitutes between-country comparison for before and after comparisons. In addition, it makes use of readily available information in the modelling process. However, the lack of control for possible confounding effects of geography, history and culture diminish the usefulness of the efforts.

Historical and cross-national studies of the impact of malaria are listed in Annex B.5.

Intangible Impacts

Malaria also has an intangible but vital impact on health. Health is both a consumption and investment good. As a consumption good, it is a characteristic valued in its own right. Like better food or better housing, better health is an attribute that increases its owner's quality of life. Most of the benefits of better health are private rather than public in the sense that they accrue primarily to the individuals experiencing better health.

Economic theory indicates that the value of a consumption good should be determined according to willingness-to-pay (WTP) methodology. Health, like food, is worth what a consumer is willing to pay for it. This methodology asks, simply, how much money a sick person would be willing to pay to get better, or how much a healthy person would pay to avoid getting ill.

Since malaria poses a substantial risk of death, particularly among children and nonimmune persons, the relevant health states must include a risk of death. Despite the theoretical virtue of the WTP methodology, severe practical constraints have meant that it has been little used in either developing or industrialized countries. Available studies from industrialized countries, however, show that this concept is extremely important, and the economic magnitudes are substantially greater than both the direct and indirect effects (Bentkover 1988). In the first instance that we are aware of in a developing country, Trangarn is currently applying the methodology to the question of the value of the economic loss from malaria in Thailand.

Macroeconomic models

Macroeconomic models of the effects of malaria incorporate secondary effects of the disease, or its control, on overall government expenditures, availability of labor and other factors. Barlow's simulation of the effects of near-eradication in Sri Lanka (1968) showed gains in production, which expanded greatly in the short-run, to be overwhelmed by the growth in population in the long-run, resulting in a net reduction in per capita income. Malenbaum (1970) used a model that related rice production in Thailand by province to reductions in malaria deaths and found no significant effect. Kühner (1971), using a national model to relate agricultural GDP from 1952 through 1966 to malaria morbidity and mortality, found large losses due to malaria that diminished over time as the malaria rate declined in Thailand.

Several authors have modelled the effects of malaria eradication on population growth, most notably in Sri Lanka. Altogether, we identified 16 documents that address this effect. The macro-level models are listed in Annex B.6.

Reviews in the literature

There have been a number of analytic and critical reviews of the literature on malaria's effects on the economy. The most recent is by Andreano and Helminiak (1988). Others are Barlow and Grobar (1986), Prescott (1979), Wernsdorfer and Wernsdorfer (1988) and Barlow (1979). In addition, there are at least 50 documents that discuss the economic impact of malaria in general theoretical terms. These are listed in Annex B.7.

3. Dimensions of Malaria in Africa

Transmission

Malaria occurs throughout Africa south of the Sahara with the exceptions of mountainous areas at high altitudes and parts of South Africa. The most important causative organism is *Plasmodia falciparum,* which accounts for more than 90 percent of all infections. Determinants of the epidemiology of malaria are immunity and transmission. Transmission depends on ecological conditions and the vectorial capacity of prevailing anopheline mosquitoes. Moderate to low temperatures, such as those found in areas of Africa free of malaria, inhibit development of the parasite in the vector. In addition, *Anopheles* mosquitoes require humidity and clean water to develop. These conditions are present year-round in the humid tropics and the vectors are abundant. In savanna areas, which experience these conditions only during the wet season, vector density and the dependent transmission vary by season.

Immunity

Immunity is the key determinant of the clinical impact of malaria. Throughout Africa, immunity varies by age. At birth a child is protected by maternal antibodies that last through the first three months of life. As these antibodies diminish, the child will suffer severe and in many cases deadly attacks in the event of infection. Each malaria attack survived produces some immunity. This immunity protects against illness and, to a lesser degree, infection (Rosenberg et al. 1990). The protection is inversely proportional to the number of parasites received from the infective mosquito. Immunity is generally specific to *Plasmodia* strains, although there is some cross-immunity. Illness, however, is more likely from infection with a previously unencountered strain (McGregor and Wilson 1988).

In an immune person, the presence of parasites in the blood does not signify illness. Brohult et al. (1981) found that physiological working capacity was not diminished by the presence of parasites in the blood of Liberian miners. Pehrson et al. (1984) report that work performance in immune Liberian workers was similar whether or not they were protected from infection.

The age at which immunity arises and its permanence vary according to the type of malaria transmission. The humid tropics, which contain 60 percent of the population of sub-Saharan Africa, constitute areas of stable malaria transmission. Here, over millennia, an adaptation has developed between man and *Plasmodia*. From the age of five years, people in these areas have protective immunity that renders attacks rare and milder than those of infancy. The drier savanna and sahel areas north and south of the forest belt, which contain 30 percent of the population of sub-Saharan Africa, constitute a region of seasonal transmission where malaria is transmitted only during the wet season. Therefore, protective immunity is attained at a later age, usually about 10 years. Populations in these areas lose some of their immunity during the dry season. If they are subject to intense transmission, serious illness can result. Thus, after prolonged periods of drought, the Sudan and northern Mali were subject to dramatic outbreaks in 1986.

The remaining 10 percent of the population of sub-Saharan Africa lives in areas of unstable malaria transmission. These are areas of high altitude or urbanization where malaria transmission is irregular and may produce epidemics.

Immunity is gradually lost in the absence of reinfection. In areas where malaria transmission is seasonal, loss of immunity between the seasons leads to peaks of morbidity during the rainy seasons (Greenwood et al. 1987). In Lusaka (Watts et al. 1990), people lose their immunity in urban areas as a result of diminished transmission and suffer clinical illness when travelling outside towns. A controversy exists as to the degree and speed with which people lose their immunity when using chemoprophylaxis. Pringle and Avery-Jones (1966) stated that after as little as one to two months of use, discontinuation would result in more attacks. Greenwood (1984) concluded from a review of the literature that antibody levels were lower in protected populations. Teams engaged in general prophylactic schemes claim that even when chemoprophylaxis was discontinued after two years, there was no significant increase in illness or mortality due to malaria in children (Bradley-Moore et al. 1985, Björkman et al. 1986, Otoo et al. 1988).

Morbidity from malaria in Africa

Malaria is characterized by successive episodes of high fever coupled with musculoskeletal pain, headache and intestinal symptoms, followed by exhaustion and weakness. An episode lasts about 18 hours. The duration of an attack depends on the level of acquired immunity and the availability and administration of effective treatment. The duration of the period during which a patient is unable to work also depends on his or her general health and nutritional status, attitude and motivation, and the type of work to be accomplished. It is a general practice in Africa to hospitalize only patients who suffer from severe forms of malaria. The duration of hospitalization is quite variable, depending not only on the severity of the case but also on the curative policy of hospitals. Table 2 summarizes some of the observations reported in the literature. One may generalize from these that, on average, a semi-immune person with uncomplicated malaria will be unable to work for 3.5 days and a child will be sick for five days.

Table 2 Duration of Malaria Attacks

Country	Duration of Illness Children days	Duration of Illness Adults days	Reference
Liberia		4.2	Miller (1958)
Ivory Coast	3.4		Imboua-Bogui & Diawara (1987)
Ghana	2-6		Colbourne (1955)
Ghana		7	Ghana Hlth Ass. Team (1981)
Togo	5.3		Deming et al. (1984)
Ethiopia		3-4	Fontaine (1961)
Rwanda	5.2		Ntlivamunda et al. (1985)
East Africa		4-9	Raper et al. (1944)
Malawi		3.4	MacDonald (1950)
Nigeria		2.6	Bruce-Chwatt (1963)
Tanzania		1.5-4	McCarthy (1941)

The examination of blood films for malaria parasites requires skilled laboratory technicians and proper equipment, including microscopes capable of high magnification and good resolution. In most African countries, the parasitological confirmation of clinically diagnosed malaria is restricted to reference hospitals from the district-level upward. Table 3 presents the results of investigations into the proportion of clinical diagnoses that were confirmed parasitologically. In general, 40 to 50 percent of clinically diagnosed cases are actually caused by malaria parasites. This percentage varies significantly between seasons. It may be above 70 percent during the period of intense transmission and lower than 30 percent during the dry period (Greenwood et al. 1987, Richard et al. 1988, Marsh et al. 1989).

Table 3 Clinical Malaria and Parasitological Confirmation

Country	Population studied	Proportion of clinical cases confirmed	Reference
Gambia	children <7, diff. months	41% -100%	Greenwood et al. (1987)
	children <7, diff. months	47% - 64%	Greenwood et al. 1988
	children <11, diff. months	0% - 89%	Marsh et al. (1989)
Burkina Faso	children <14, diff. age groups	8% - 40%	Baudon et al. (1988)
	all ages	32% - 40%	Gazin et al. (1988a)
Nigeria	children, hospital Ibadan	37%	Hendricks et al. (1971)
	children, hospital Ibadan	48%	Salako (1987)
Gabon	children <7	28%	Richard-Lenoble et al. (1988)
Congo	all ages		Richard et al.

The quarterly statistical report of the World Health Organization, which reports malaria statistics from much of the world, does not give information on the number of malaria cases reported from Africa south of the Sahara (WHO 1987) because reporting is incomplete and grossly underestimates the actual number of cases. In the past the incidence of malaria has been studied in small cohorts. The figures given by MacDonald (1950), Miller (1958), Bruce-Chwatt (1963) and McGregor (1987) indicate an average of one to seven attacks per child per year and one to two attacks per adult per year. The experience of the CCCD programmes in Africa did not differ substantially from these estimates: four to nine attacks per child younger than five years of age (Breman and Campbell 1988). Factory workers in Burkina Faso told Gazin et al. (1988b) that 17 percent of them had experienced an attack of malaria during the preceding six weeks. These data extrapolate to 1.5 attacks per adult per year.

If one calculates the number of cases one would expect in a given country based on these rates, the numbers usually far exceed the actual reported figures. The difference can best be explained by the fact that the health services in most countries reach only a part of the population. Only eight percent of malaria patients in Guinea, 21 percent in Togo and 41 percent in Rwanda consulted a health station (Ntilivamunda et al. 1985, Deming et al. 1984).

Table 4 Coverage of Health Services and Self Protection Against Malaria

Country	Proportion using health services	Proportion using self-treatment	Proportion using chemo-prophylaxis	Proportion using other protection	Reference
Guinea	8%	19%			Breman & Campbell (1988) Ntilivamunda et al.(1985)
Burkina Faso					
urban		28% - 36%	28% - 57%	12% - 83%	Sabatinelli et al. (1986)
rural		28% - 62%	1% - 82%	0% - 16%	
Ivory Coast	78%		30%		Imboua-Bogui et al.(1987)
Ghana					
urban		87%	37%	81%	Lobel & Beier (1989)
rural			94%	3%	
Togo	21%	84%			Deming et al. (1984)
Equatorial Africa	0% - 93%				Merlin et al. (1986)
Cen. African Rep.	13%	71%			Breman & Campbell (1988) WHO (1989)
Congo		89%			Breman & Campbell (1988)
Zaire	71%	47% - 92%			Breman & Campbell (1988) Greenberg et al.(1989) Ntilivamunda et al.(1985)
Kenya	82%	73%			Kaseje et al. (1987) Mburu et al. (1987)
Rwanda		21%	47%	30%	Breman et al. (1988) Ntilivamunda et al.(1985)
Zambia			35% - 50%		Watts et al. (1990)

Table 4 compares rates for several countries. The utilization of health services may change drastically as a result of the change in health policy. An 85 percent drop in attendance was experienced in Ghana in 1986, when user charges were introduced (Waddington and Enyimayew 1989). Similar events will also cause the number of reported malaria cases to fall. As can be seen from Table 4, most malaria patients never come to the attention of health services at all because of the widespread practice of self treatment, practiced by more than three quarters of the population in many countries. Nevertheless, malaria is the primary cause of most consultations in outpatient services and hospitalizations (Table 5).

Table 5 Malaria admission rates

Area	Population	Admission rate (%)	Remarks	Reference
Zanzibar	Children	37.0	Hospitalized	Ministry of Health (1988)
	All ages	48.0	Hospitalized	
Malawi	All ages	30.0	Hospitalized	Ministry of Health (1988)
	All ages	43.0	Outpatients	
Rwanda	All ages	9.0	Hospitalized	Ministere Sant (1989)
Uganda	Children	5.3	Hospitalized	Williams et al. (1986)
	Adults	0.6	Hospitalized	
Sudan	All ages	58.1	Hospitalized	Mashaal et al. (1987)
Zaire	Children <12	38.2	Hospitalized	Greenberg et al. (1989)
Ghana	Children <5	43.0	Outpatients	Lobel & Beier (1989)
	Children <5	59.0	Hospitalized	
	All ages	42.8	All health services	
Togo	All ages	34.0	Outpatients	Lobel et al. (1990)
Burkina Faso	All ages	21.4	Hospitalized	World Bank (1982)
	All ages	25.9	Outpatients	
Burkina Faso	Children less	22.9	Hospitalized	Baudon et al. (1988)
	Children 2-4	13.4		

Most African countries do not require death certificates. Data on malaria mortality can be obtained only from large hospitals. A representative study of Greenberg et al. (1989) reports a minimum specific mortality of one per thousand in children under 12 years of age in Kinshasa. The case fatality was found to be 21.1 percent. Table 6 gives an overview of the results from different studies.

Table 6 Malaria mortality in different countries of Africa

Country	Specific mortality per 1000	Case fatality %	Remarks	Reference
Senegal	24%		All ages	Laing (1984)
Gambia	11.0	14%	Children 1-4 yrs.	Greenwood et al. (1987)
Ghana	2.3		Children <15 yrs.	Colbourne & Eddington (1954)
Nigeria	5.4 - 7.9		All ages	Bruce-Chwatt (1952)
Congo	0.4	6%	Children <15 yrs.	Trape et al. (1987)
Zaire	1.0	21%	Children, Kinshasa	Greenberg et al. (1989)
Zaire	3.0		All ages, Kivu	Delacollette et al. (1989)
Zaire	12%		All ages, Ituri	Janssens et al. (1966)
Kenya	24%		All ages	Okelo et al. (1987)
Rwanda	0.2	2%	All ages	MOH Rwanda (1989)
Zambia	5.1		All ages	MOH Zambia (1989)

Resistance to chloroquine complicates malaria control

In 1979, the first case of confirmed chloroquine resistance was reported from Africa (Onori 1984). Since then, resistant strains have spread to all African countries. Increases in prevalence have been explosive. In Cameroon, resistance was not reported until February 1985. Only eight months later, *in vitro* tests showed a prevalence of 86 percent in African children (Brasseur et al. 1988). In Madagascar, a rise from around 10 percent to above 30 percent occurred in 1988 after a reduction in the price of chloroquine in 1987, which led to uncontrolled use by the population (Lepers et al. 1989). In most countries, chloroquine resistance at the RI-RII level is presently found in 25 percent to more than 60 percent of children. Data for several countries are contained in Table 7.

Table 7 Chloroquine resistance in Africa

Country	Year	Level	Chlor. Dose	% resist in vivo	% resist in vitro	other resist	Reference
Liberia	1989	RI-RII		28%	confirmed	30% Fansidar	Monson et al.(1989)
Ivory Coast	1986	RI-RII	25mg	1%			Breman et al.(1988)
Ghana	1988	RI-RII	25mg	19%	59%		Lobel & Beier (1989)
Togo	1988			27%-40%			Lobel et al.(1990)
Benin	1989			18%-46%	3-11%	Mefloquine	Chippaux et al.(1989)
Niger	1989	RI-RII	25mg	35%	7%		Buck & Gratz(1990)
Nigeria	1987	RI-RII	25mg	35%			Breman et al.(1988)
Nigeria	1989	RI-RII	25mg	25%			Daniel & Molta(1989)
Cameroon	1985			86%	39%	Quinine	Brasseur et al.(1988)
Cameroon	1989	RIII	25mg	39%	confirmed		Odoula et al.(1989)
Cen.Afr.	1986	RI-RII	25mg	5%			Breman et al.(1988)
Zaire	1985	RI-RIII	10mg	74%-91%			Paluku et al.(1988)
Zaire	1988	RII		44%-95%			Cutts et al.(1990)
Sudan	1989	RIII		24%			MOH Sudan (1990)
Kenya	1988	RI-RII		20%-50%			Watkins et al.(1988)
Rwanda	1986	RI-RII	25/50mg	59%/29%	confirmed		Sexton et al.(1988)
Rwanda	1987	RI-RIII		66%		34% Fansidar	Garcia-Vidal et al.(1989)
Malawi	1985	RI-RII	10/25mg	84%/57%			Breman et al.(1988)
Zambia	1986	RI-RIII	25mg	10%-41%	confirmed		Lemnge & Inambo(1988)
Tanzania	1983	RII	19%	19%		5% Fansidar	Kilimali et al. (1985) a,b
Mozambique	1987	RI-RIII	25mg	70%	71%	16% Fansidar	Schapira(1988)
Madagascar	1988	RI-RII	25mg	29%-33%	28%		Lepers et al.(1989)
Swaziland	1985	RI-RII	10/25mg	82%/47%			Breman et al.(1988)

Malaria trends

Over the last decade, many African health officials have observed that malaria is more frequent and causes more illness and even mortality than before. A search of the epidemiology literature on malaria in Africa yielded approximately 1,000 titles, of which about 300 have been studied in detail. However, hard evidence on patterns and trends of morbidity and mortality, especially in adults, is scant and often restricted to special situations. Data are often based on relatively small samples or on selected populations. To draw a general picture, findings have to be generalized to different areas and countries. Extrapolations outside the range of the data assume that development observed over a past period will continue in the same manner into the future, including factors like climate, social stability and general development.

For three countries, Togo, Rwanda and Zambia, data are available on the number of malaria cases per 1000 inhabitants per year over several years (Lobel et al. 1990, Rwanda 1989, Zambia 1989 respectively). In the absence of a specific model including all factors governing the incidence of malaria, a simple exponential growth curve has been applied to the available data. The values projected on the basis of these curves show annual incidence growth rates of 7.3 percent for Zambia, 10.4 percent for Togo and 21.2 percent for Rwanda. Hospital data reported from Zambia indicate that mortality is rising 5.2 percent per annum in children and 9.7 percent in adults. Figures 1 and 2 show the fitted lines; Table 8 contains regression and correlation coefficients.

Table 8 Exponential Trends in Malaria Incidence

Natural (base) Logarithm of Cases/1000	Intercept	Slope	R^2
Rwanda	2.207	0.192	0.978
Togo	1.293	0.099	0.791
Zambia	5.240	0.070	0.946

A growing number of persons, particularly in urban areas, use chloroquine for self treatment and chemoprophylaxis, as well as other means of protection against malaria (Table 4). Malaria vectors find fewer breeding places in urban areas than in rural areas. Self protection and lack of exposure lead to a loss of immunity (Watts et al. 1990). Those eventually infected are likely to suffer a more severe illness.

Furthermore, development has resulted in increased migration, which exposes people to new strains of malaria parasites that they have little or no immunity against. Bruce-Chwatt (1968) has pointed to the downhill movements of highlands populations in Ethiopia and Kenya that have led to outbreaks in the past. Packard (1986) describes how labor migration has led to a constant reimportation of malaria to Swaziland despite all control efforts. In recent years, malaria has been observed in high altitude areas of Rwanda where it was not previously transmitted (Gascon et al. 1988). It is not clear whether this is due to an importation from the lowlands or is a result of global warming that permits the development of parasites. Both will lead to more severe attacks, even in adults.

New development may also encourage vector breeding. Borrow pits, road works, and other environmental changes create new breeding sites. Such areas may also experience large in-migration of nonimmune workers and their families.

Because of parasite resistance to chloroquine, the required dose is double that of the past. However, public awareness about proper dosage of chloroquine is insufficient (Breman and Campbell 1988). Attempts at self treatment are often inefficient and may result in severe cases, which come to the attention of health professionals at a late and critical stage. Because of the widespread and uncontrolled use of chloroquine, resistance is likely to increase further. By 1992, chloroquine will probably have to be used in combination with other antimalarials in many countries and by 1995, it may have to be completely replaced by alternative drugs. Unfortunately, resistance to all other antimalarials, including quinine, has been reported from some African countries. It is likely that resistance to these alternative drugs will spread from the moment they are used in larger amounts.

The reasons for the rise in the number of malaria cases and their severity in Africa are intimately linked to development. Skilled workers are likely to move frequently to different areas and even different countries. They will need to avoid attacks of fever in order to perform. These workers and the members of their households are likely to make use of chloroquine prophylaxis, particularly with the price of chloroquine relatively low. It can therefore be predicted that

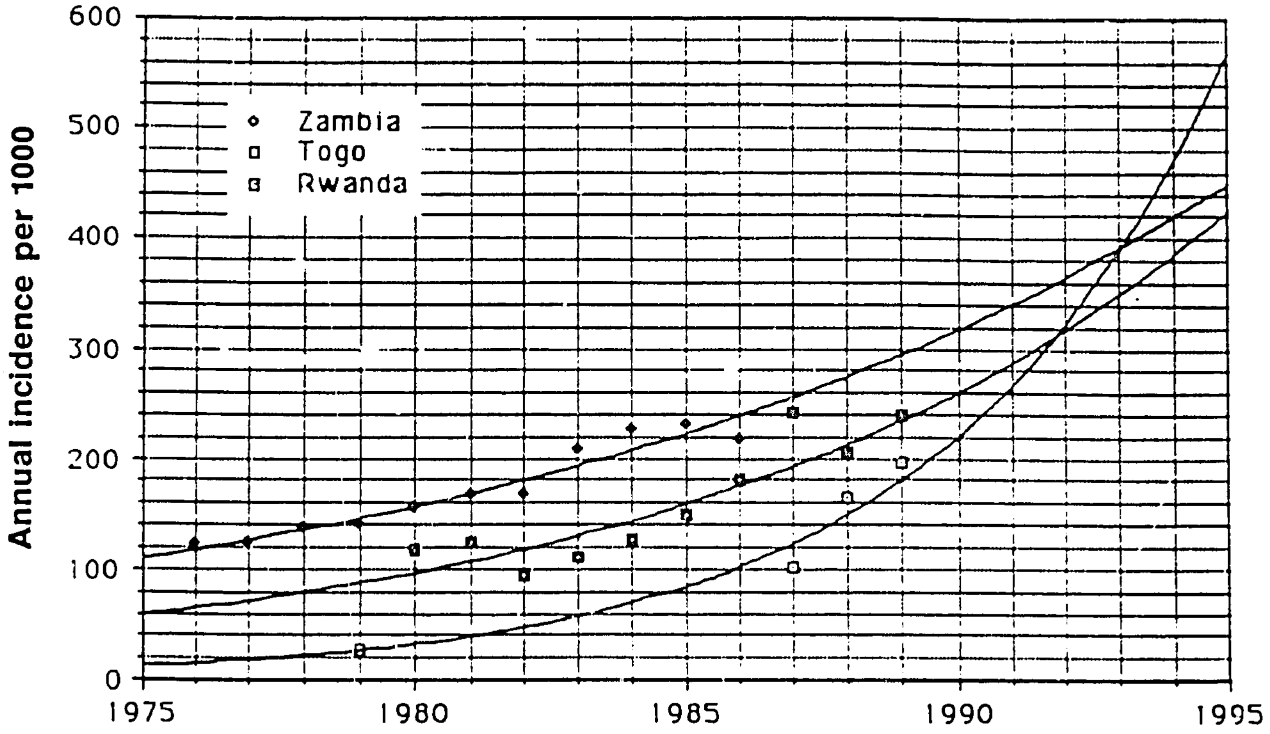


Figure 1 Trends in malaria incidence in three African countries

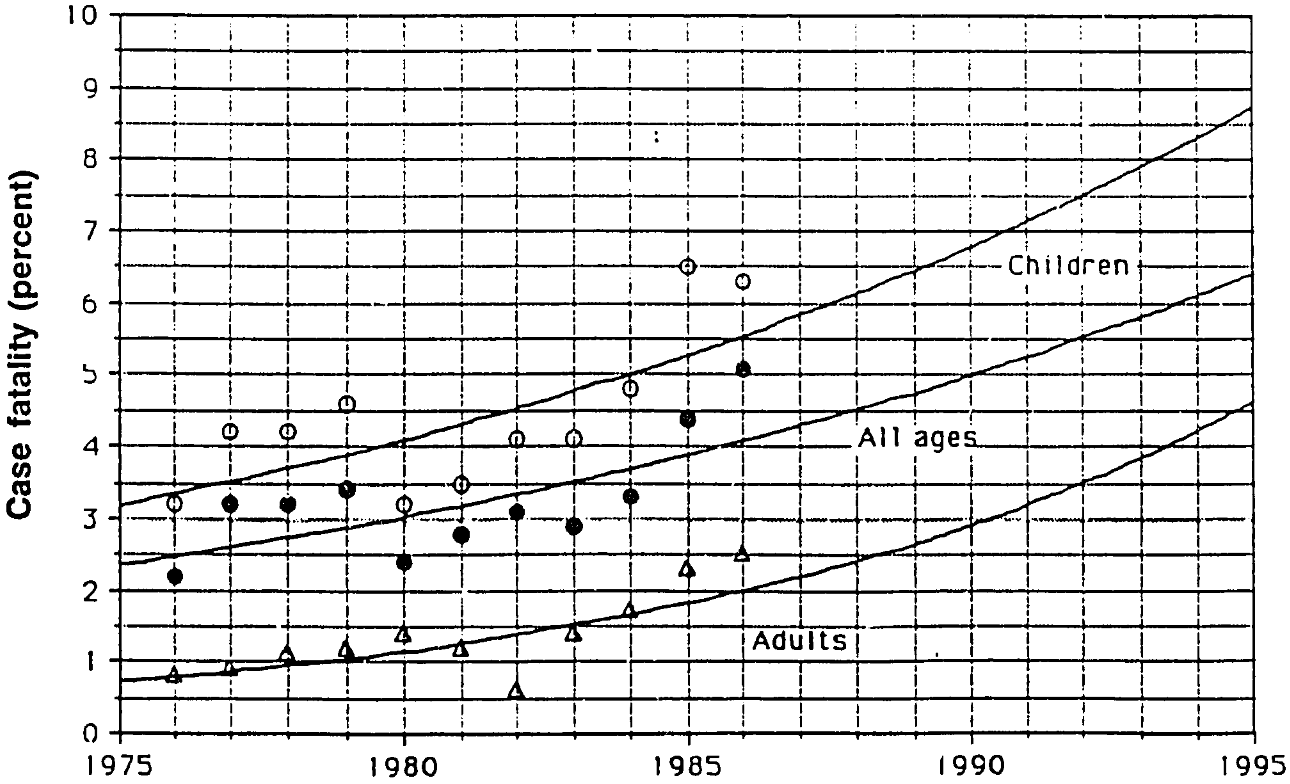


Figure 2 Trends in case fatality in Zambia

in areas of intense development, large proportions of the population will increasingly be at risk of malaria. The threat of intensive malaria transmission in peri-urban and rural areas will remain. These risks, coupled with an important and rising resistance to antimalarial drugs, will create an unstable situation. The result will be an increase in attacks and severe cases of malaria and the risk of outbreaks and epidemics (Onori and Grab 1980).

The experience of Sao Tome and Principe may serve as an example. After a successful eradication campaign between 1980 and 1981, surveillance was neglected. Malaria was reintroduced by migrant fishermen in 1983. In 1986, a malaria epidemic occurred that killed more people in ten months than had died of the disease in the seven years before implementation of control measures. Madagascar also experienced epidemic malaria when transmission was reestablished after a period of eradication.

4. Case Studies from Africa

To further examine the economic impact of malaria, four case studies of countries or regions were performed. The sites were chosen based on availability of data and useful methodological elements. One case -- Rwanda -- examines a national situation where there are excellent epidemiological and cost data from health facilities; the emphasis is on government and societal impacts of malaria. The case in Burkina Faso derives from household surveys on production and illness, and the perspective is that of families and communities in a single district. In the case from Chad, epidemiological data from public sources and expenditure figures from individual surveys were combined to examine malaria impact. The case of Brazzaville depends almost entirely on special research findings, fortuitously located through routine literature searching, and examines not a rural but an urban industrialized economy. The cases, then, represent the range of types of malaria and availability of data in Africa.

Trends in economic growth and urbanization affect the impact of malaria, as described above. The historic trends in urbanization and economic growth, measured as per capita GDP, for each of the four case study countries and sub-Saharan Africa as a whole, are shown in Figures 3 and 4.

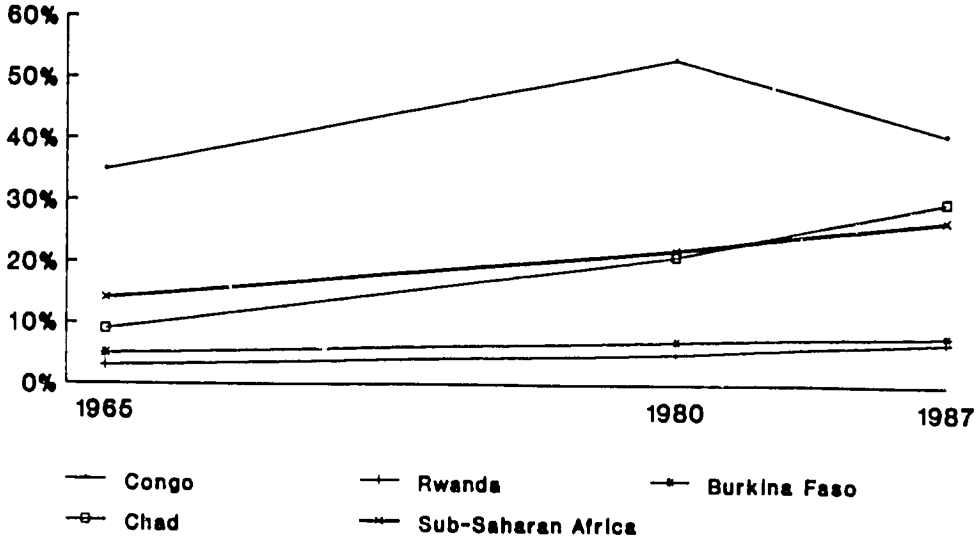
Methodology

Epidemiological data for each case are taken from documents or reports that provide the most complete picture for the particular year: 1989 for Rwanda, 1987 for Chad, 1984 for Brazzaville, and 1985 for Solenzo. The epidemiological numbers are applied to the population at that time. All persons younger than 15 years old are defined as children and those 15 and older as adults. Only adults are considered economically active in this analysis, although children are known to contribute to household economic production in many areas. All economic data, gathered from a number of sources and years, have been converted to 1987 US dollars using exchange rates and domestic price deflators from the 1988-89 World Tables of the World Bank (1989b).

The direct costs of malaria for each case have been estimated by applying known or assumed costs of treatment either at home

Fig. 3

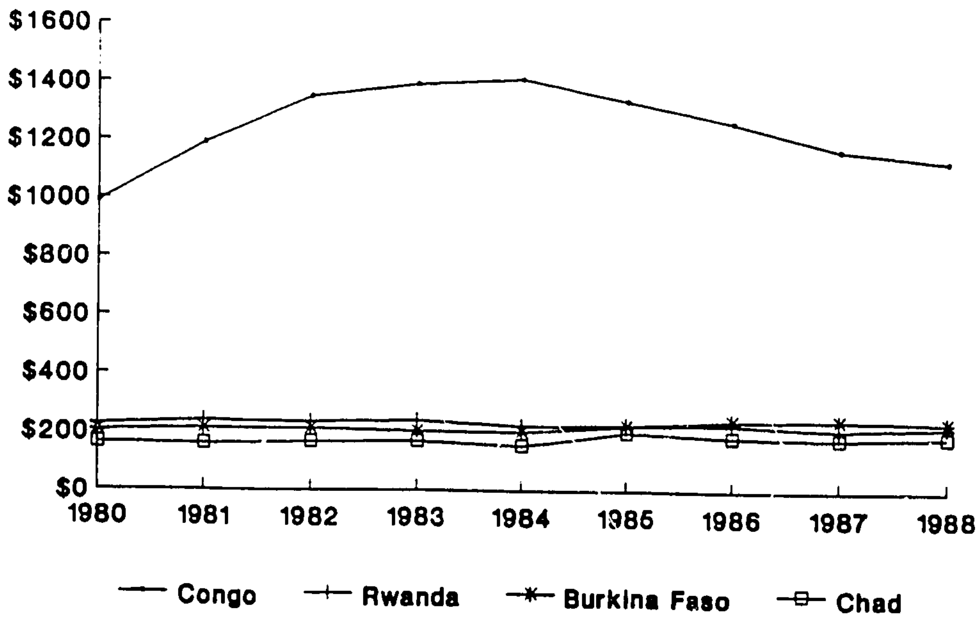
Urbanization Trends in Africa: Urban Populace as Percentage of Total Population



Source: World Bank, 1989a.

Fig. 4

Economic Trends in Africa Per Capita GNP (1980 US Dollars)



Source: Calculated from data in World Bank, 1989b.

or in a health facility to the number of clinical cases. Indirect costs have been estimated by applying a calculated output per day for adults to the known or assumed time loss of both adult and child cases. Adult time loss is assumed to be 100 percent for the duration of the illness time in adult cases and approximately 30 percent for the duration of illness in child cases in which an adult must tend the sick child. The present value of future earnings lost due to child mortality is based on a method described by Shepard et al. (1986) from another African health study. Other assumptions and details are explained for each case.

A projection of the economic impact of malaria in 1995 has been made for each case. Population projections to 1995 use an average annual rate of increase (World Bank 1989a). The rate of growth for Brazzaville is for the urban population. For the Solenzo and Chad cases, the rate is a calculated average for each country's rural population. In the case of Rwanda, the national rate is applied. These rates are show in Table 9 below.

Table 9 Annual Population Growth Rates for Projections

	National Rate	Rural Rate	Urban Rate
Burkina Faso	2.9%	2.7%	8.0%
Congo	3.6%	2.9%	4.6%
Rwanda	3.8%	3.5%	7.0%
Chad	2.6%	0.4%	30.0%

Again, the economic projections use 1987 US dollars. The growth of real GDP is calculated for the agricultural sector for Solenzo and Chad, for the industrial and service sector for Brazzaville, and for the nation as a whole for Rwanda from World Bank data (World Bank 1989a). The rates are shown in Table 10 below.

Table 10 Annual Economic Growth Rates Used in Projections

	Total GDP	Agricultural Sector	Industrial/Services Sector
Burkina Faso	5.6%	6.1%	5.3%
Congo	5.5%	1.5%	6.0%
Rwanda	2.4%	1.1%	3.2%
Chad	5.1%	2.6%	7.0%

The occurrence and notification of episodes of malaria depends on a number of factors. The most important are: intensity of transmission, level of immunity in various sub-populations, utilization and quality of health services, quality of recording, and availability of drugs. Projections require a solid understanding of the relationships among these factors and their current status. Such a model does not yet exist.

Projections of the growth in epidemiological parameters are based on the estimates described above (Table 8), applied to each case as needed. Rates for each case study area are given below in Table 11.

Table 11 Annual Malaria Incidence Growth Rates Used in Projections

Burkina Faso	10.4%	(Togo rate)
Congo	7.3%	(Zambia rate)
Rwanda	21.2%	(Rwanda rate)
Chad	10.4%	(Togo rate)

Projections of future trends in malaria epidemiology suggest that treatment costs will increase with the increased cost of drugs due to chloroquine resistance. The average cost of an adult treatment episode with chloroquine may increase from $0.07 to $0.14 as dosage requirements increase. Alternative drugs may be required. These range in price from the relatively inexpensive sulfadoxine/pyrimethamine combination at around $0.10 per treatment episode to mefloquine at $6.00. Projections in the case studies are calculated with a simple doubling of the price of antimalarial drugs.

Both initial estimations and the projections of the economic impact of malaria for each case have been expressed as per capita and per case costs.

Solenzo Medical District, Burkina Faso, 1985

Solenzo Medical District lies in northwestern Burkina Faso. The population is engaged in agriculture and is prosperous compared to residents of more northern areas of the country. The primary crop produced is millet. This case is based on a household survey in a rural population of 6,442. Detailed information on household expenditures, morbidity, mortality, and agricultural production was gathered in 1985. Malaria cases, therefore, are those illness episodes reported as malaria by the individuals interviewed.

From these data, estimates of the value of time in each of three seasons of the year were determined. The maintenance season of January and February is when farm households carry out necessary repairs to houses, fences and equipment. Some income-producing activities, such as brewing of millet beer and mat weaving, may be carried out as well. The residents of Solenzo traditionally visit the doctor during this season. One day of adult time during this period was valued at $0.28. This figure was based on the calculated value of time spent on brewing and other activities that have a market price. Other maintenance activities in the household cannot be so easily valued, although they are certainly vital to the prosperity of the family.

The rest of the dry season (March and April) is used to produce cash crops such as cotton. Approximately 50 percent of the men in the district are engaged in production of cash crops during this season. Adult time during this period had a value of $1.09 per day. This figure was calculated by dividing the total market value of the cash crop of the surveyed population by the adult-days available during the two months.

The rainy season months of May through December are a time of intensive food production for the household. Approximately 15 percent of this production is sold for cash income. Land is readily available for food production. The limiting factor is the availability of labor. Adult time during this very important period was valued at $0.55 per day, calculated by dividing the total market value of the crop produced by the available adult-days.

Economic and epidemiological data for this case were derived from a 1985 household survey in Solenzo. The population has been described in detail elsewhere (Sauerborn et al. 1989). Epidemiological data from a recall survey have been expanded to a twelve-month period and seasonally adjusted using national monthly morbidity data provided by the Burkina Faso Ministry of Health reports. All other values used in the case derive directly from the survey findings or from Dr. Sauerborn's long residence in the district.

In 1985, a total of 1,326 malaria cases were reported by this community, more than 70 percent of them in children. Approximately 75 percent of all cases occurred during the busy food production season. An estimated loss of 1,634 work days can be ascribed to malaria morbidity. This is probably a low estimate because reported severe cases were more numerous among adults, suggesting that illness in children may remain untreated and reported. More detailed data on the epidemiological and cost calculations are contained in Annex A.1.

Treatment of malaria cases was relatively expensive. A mild case cost the family an average of $7.77, 25 percent of which was spent on transportation. A severe case cost on average $9.82, of which 15 percent was transportation expenses. A fatal case cost $16.27, including about $4.07 for transportation.

In 1985, the total cost of malaria per capita averaged $2.37 in Solenzo: $1.65 direct costs of transportation and treatment and $0.72 indirect cost of child mortality and adult time lost from productive activity (Fig. 5). During the same period, the cash income per capita was $0.12 per day and output per capita was $0.31 per day. Therefore, direct, out-of-pocket cost of malaria represented approximately 14 days of cash income per capita. The total cost of malaria represented more than one week of production.

The projected impact of malaria in 1995 is shown in Fig. 6. The population of Solenzo was assumed to experience the annual 2.7 percent increase projected for rural areas of Burkina Faso. Production was assumed to reflect the annual 6.1 percent increase for the agricultural sector. Malaria incidence rates were assumed to increase annually by 10.4 percent, with no change in the ratio of severe to mild cases. Adult deaths are assumed to rise to 10 percent of total deaths and drug costs of treatment are assumed to double due to the spread of chloroquine resistance. Details of the calculations are provided in Annex A.1.

Fig. 5 Cost of Malaria in Solenzo District 1985

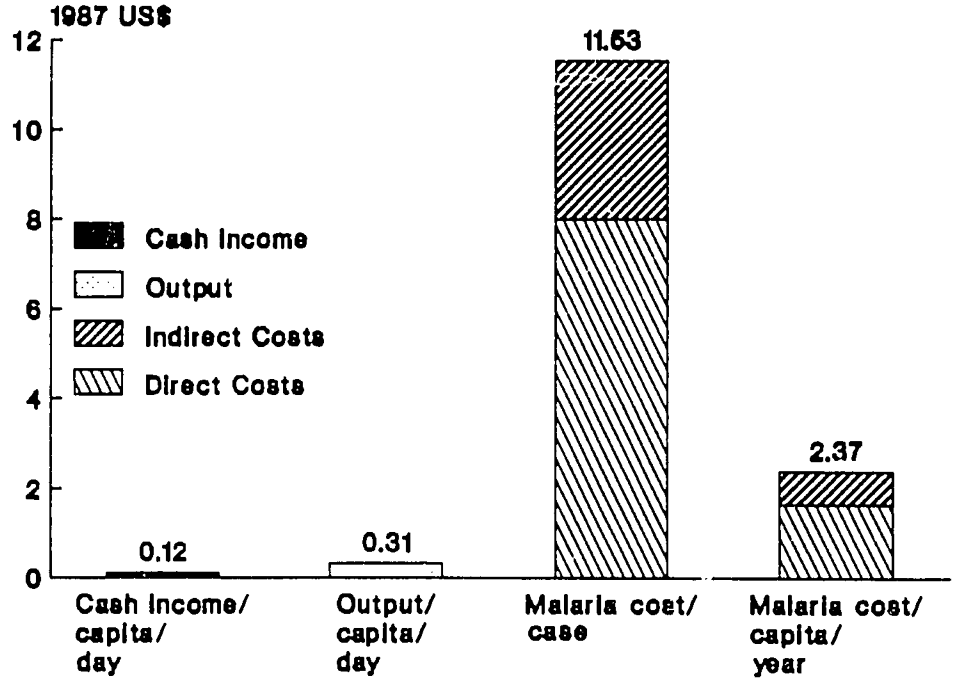
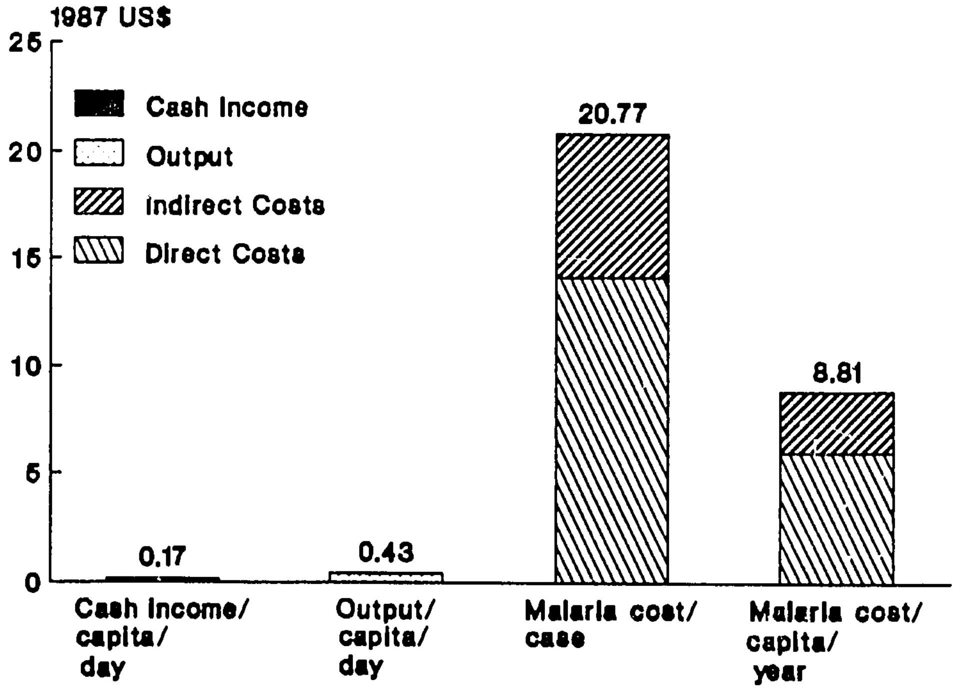


Fig. 6 Cost of Malaria in Solenzo District Projected 1995



By 1995, the number of malaria cases is expected to have risen to 3,568 in a population of 8,409 persons, resulting in 4,396 work days lost. The cost of malaria in Solenzo is expected to have risen to $8.81 per capita: $5.98 direct cost and $2.83 indirect cost. Per capita output is expected to drop $0.43. In this scenario, the per capita cost of malaria will represent over 20 days of production, more than a doubling of the impact in 1985.

Mayo-Kebbi District, Chad, 1987

The case describes malaria in Mayo-Kebbi District in southern Chad. The region is of the savanna type, with seasonal malaria transmission. The population of 650,179 are farmers, producing cereals, cotton and livestock.

The number of malaria cases in the district is estimated from the medical reporting system of the country, which does not include a special designation for malaria. Fever, as defined by the system, corresponds to a clinical diagnosis of malaria. The proportion of true malaria among the clinically diagnosed cases varies by season. During periods of high transmission, a fever is more likely to be malaria. No investigations of this relationship have been carried out in Chad. Data from Gambia and Burkina Faso have been used to model the weighted proportions. Details are provided in Annex A.2.

Rates for adults and children are based on the age distribution of malaria cases in Burkina Faso (8 percent adult), assumed to be similar to those for Chad. The estimated case fatality rate among children of 6 percent is also based on Gambian rates (Greenwood 1987). There are no adult deaths from malaria.

The number of fever cases reported in Chad is less than the true total due to incomplete coverage of the system. According to Lippeveld (personal communication 1990), coverage is approximately 80 percent in the savanna zone where Mayo-Kebbi is located.

The value of time and production in Mayo-Kebbi is based on findings from a survey carried out in 1985 (Carrin 1986), which found that per capita income for the district was $45.27, including $24.72 in cash income. Direct expenditure on treatment was also estimated from data from Carrin at $0.07 for children and $0.20

for adults. Travel costs for treatment were assumed to be 66 percent of the total direct cost.

Based on these estimates, there were 30,302 cases of malaria in Mayo-Kebbi in 1987: 27,878 among children and 2,424 among adults. There were 1,673 deaths among children. The cost of malaria per capita was $0.60: $0.01 direct cost and $0.59 indirect cost (Fig. 7). These per capita costs represent five days of individual production. The relatively high indirect cost reflects the high child mortality.

Projections assume an annual rural population growth in Chad of 0.4 percent, agricultural sector growth of 2.6 percent and incidence rate growth of 10.4 percent. Adult deaths are assumed to rise to 10 percent of total deaths.

Based on these assumptions, projections of the malaria situation in Mayo-Kebbi in 1995 predict a total of 69,022 cases and 4,234 deaths, including 423 in adults, in a population of 671,278. Income per capita is predicted to have risen to $74.92 per year. Malaria cost per capita will reach $3.16: $0.04 direct and $3.12 indirect costs (Fig. 8). Therefore, malaria costs will represent 15 days of individual output, three times the burden in 1987.

Notes: Data from the national medical reporting system (BSPE 1987 and 1988), research in other countries (Baudon et al. 1988, Gazin et al. 1988, Greenwood et al. 1987, and Marsh et al. 1989) and the personal experience of Dr. Theo Lippeveld were used for estimating epidemiological parameters. Costs of treatment and per capita income are taken from Carrin 1986. Population figures from the most recent estimation which are in press were made available by Dr. Lippeveld (BSPE 1990).

Fig. 7 Cost of Malaria in Mayo-Kebbi 1987

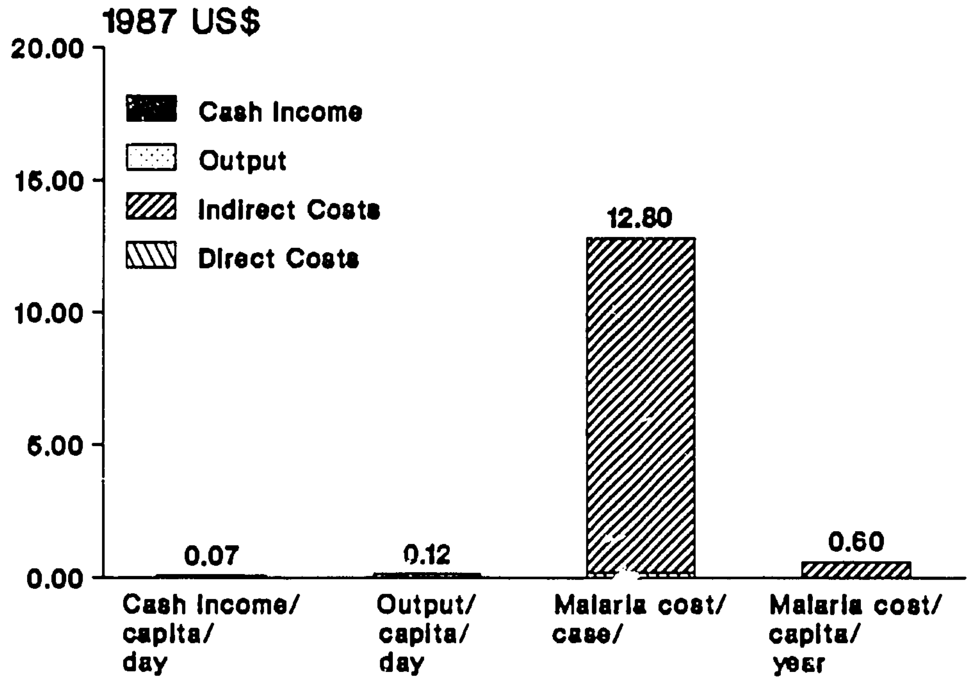
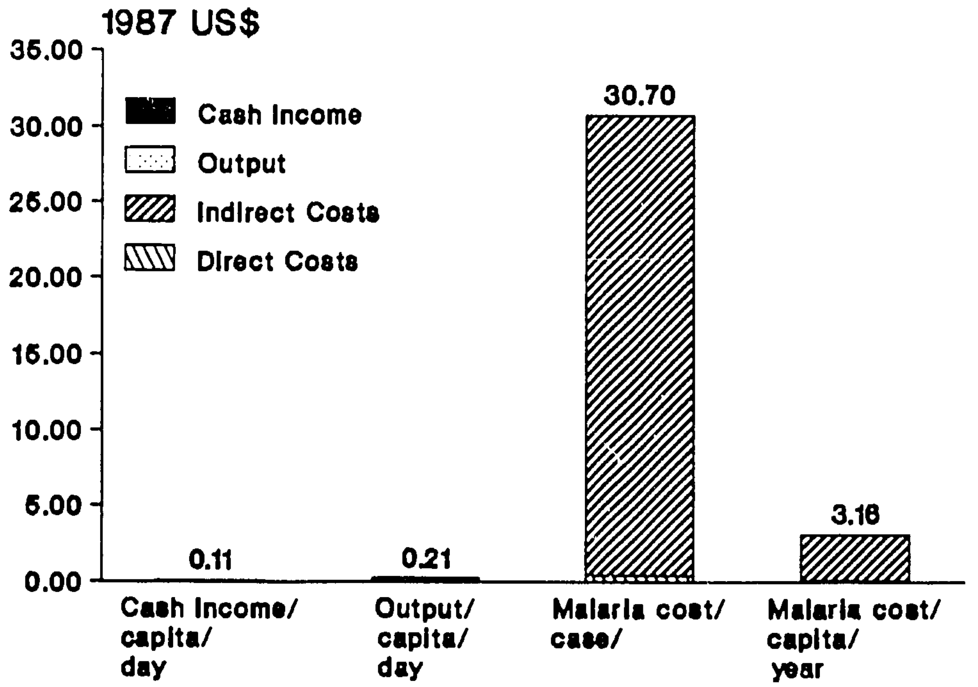


Fig. 8 Cost of Malaria in Mayo-Kebbi Projected 1995



Rwanda, 1989

Rwanda is a central African country of approximately 7 million inhabitants in 1989, the year on which this case study is based. Ninety-three percent of the population is rural and engaged in agricultural activity.

Data on the numbers of malaria cases by facility were obtained from a computerized information system that includes all malaria cases treated in both public and private health facilities (Rwanda 1990). This study uses the data on numbers of clinically diagnosed cases, with adjustments. The system also reports numbers of microscopically diagnosed cases, but that count is limited by the lack of laboratory capability in some facilities.

Additional population and budget data were obtained from government documents (Rwanda 1990). Daily costs of outpatient and admitted cases in facilities and data on rural income and expenditures were available from estimates by Shepard (1988) and Shepard and Nyandagazi (1988). Information on treatment of cases not reported by health facilities was provided by government officials and from Dr. Shepard's long experience with the Rwandese health system. Additional economic data was obtained from unpublished documents.

Malaria incidence in Rwanda has risen eightfold since 1979. In 1989, one in every five Rwandese experienced a malaria attack severe enough to warrant attendance at a health facility. Of these, approximately nine percent were admitted for treatment. The cost of treating these cases in public facilities was equal to 19 percent of the operating budget of the Ministry of Health, which was $10,760,911. Altogether, there were 1,732 deaths from malaria in 1989.

Discussions with officials of the Ministry of Health, as well as surveys, suggest that 85 percent of malaria patients are treated by a health facility. An additional 10 percent purchase drugs from a pharmacy or other market vendor, and the final five percent receive traditional treatment. It is thought that most symptomatic cases receive some form of treatment. However, a study of children younger than five (Ntilivamunda et al. 1985) found that only 41 percent were seen by a health worker.

The primary health care system in Rwanda is extensive and well-attended. One serious constraint, however, is the periodic absence of antimalarial drugs in rural government facilities. This problem may become more acute in the future because the Ministry of Health budget for drugs was cut by 42 percent in 1989.

The largely agricultural economy of Rwanda has suffered since 1987 from drought and a decline in world coffee prices, the prime export commodity. Many economists believe that the Rwandese currency is overvalued and requires a 50 percent devaluation in the near future to restore the economy's growth. This would effectively double the cost of antimalarial drugs, which must be purchased in the international market. In addition, the population of Rwanda is growing at 3.8 percent per year, one of the fastest rates in Africa.

In the calculation of the impact of malaria in Rwanda, the value of time was estimated at $1.01 per day per adult. The cost of treatment varied by the type of facility, as did the duration of treatment in admitted cases. Details may be found in Annex A.3. Of the total of 1,712,015 cases (including the 15 percent not attending a health facility), 60 percent are assumed to be children. Of the total of 1,732 deaths, 90 percent are assumed to be children.

The total cost of malaria in Rwanda in 1989 was $1.35 per capita: $0.53 direct costs and $0.83 indirect costs (Figs.# 9 and 11). (Here, and elsewhere, components may not sum to totals due to rounding.) During the same year, per capita daily output was $0.83. Thus, the cost of malaria represents more than 1.5 days of individual production. However, the total cost per case of malaria was $5.60: $2.19 direct and $3.42 indirect costs. Rural cash income averaged only $0.09 per day; therefore, the out-of-pocket expenses for a case of malaria represented 24 days of individual cash income, a significant drain on limited household resources (Fig. 11). Rural output per day was only $0.41 per capita, so malaria costs represented more than three days of individual production.

Malaria cases represented 40 percent of all ambulatory cases treated in facilities and 60 percent of all hospitalized cases. In comparison, diarrheal disease represented only five percent of ambulatory cases and 5.6 percent of hospitalized cases. AIDS cases accounted for 0.6 percent of hospitalized patients and 0.1 percent of ambulatory cases.

The projection of the impact of malaria in 1995 assumed an annual population growth of 3.8 percent and an annual growth in

GDP of 2.4 percent. The number of malaria cases and deaths was assumed to increase annually by 21.2 percent and the proportions of child cases and severe cases (those admitted to facilities) were assumed to remain constant. The cost of drugs was assumed to double due to chloroquine resistance. In addition, the real cost of drugs and supplies was assumed to double again due to the probability of devaluation. Drugs represent from 18 percent to 32 percent of the cost of treatment in facilities, depending on type of facility, and drugs and supplies from 23 percent to 36 percent. Details of the calculations are contained in Annex A.3.

Projection of the cost of malaria in 1995 is shown in Figures 10 and 12. Total cases are estimated to have risen to 4,477,347. Cost of malaria per capita is \$3.53: \$1.74 direct and \$1.79 indirect cost. At the same time, the Ministry of Health budget per capita is projected to decrease to \$1.47 and GDP per capita to \$0.80. However, income in rural areas is projected to increase marginally to \$0.43 per capita (Fig. 12). Therefore, in 1995, the direct expenditure on malaria per capita will exceed Ministry expenditure per capita. Total malaria costs will represent more than eight days of individual rural production.

Fig. 9 Cost of Malaria in Rwanda 1989

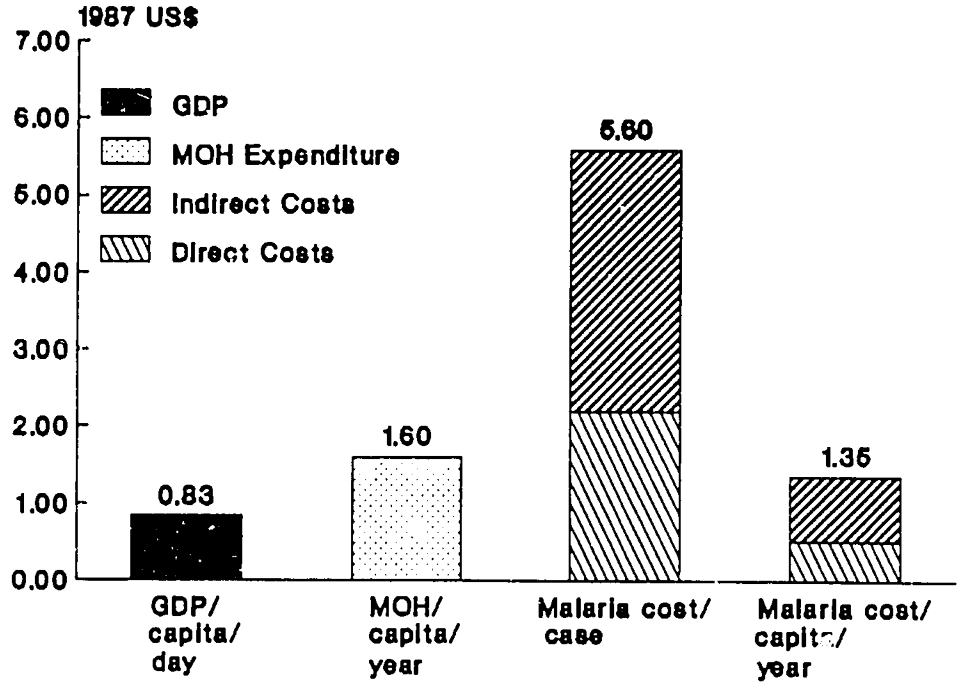


Fig. 10 Cost of Malaria in Rwanda Projected 1995

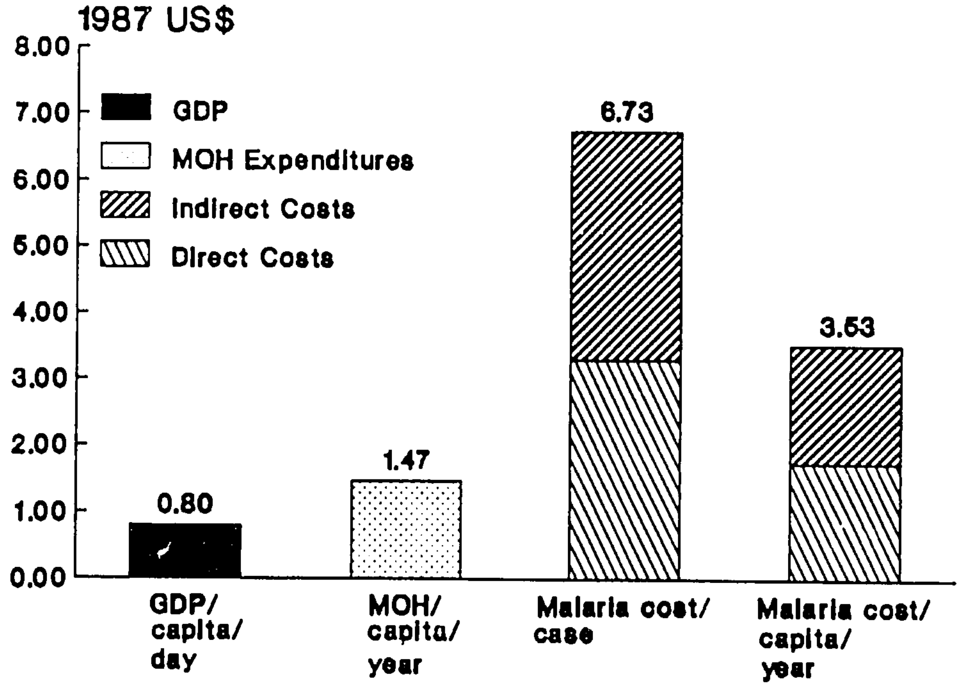


Fig. 11 Cost of Malaria in Rural Rwanda 1989

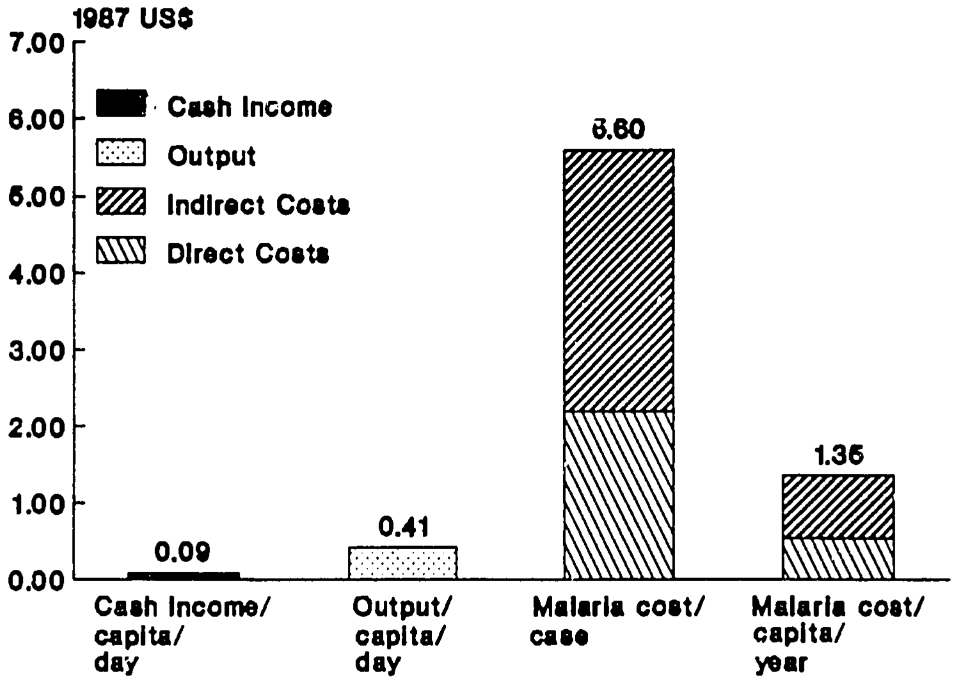
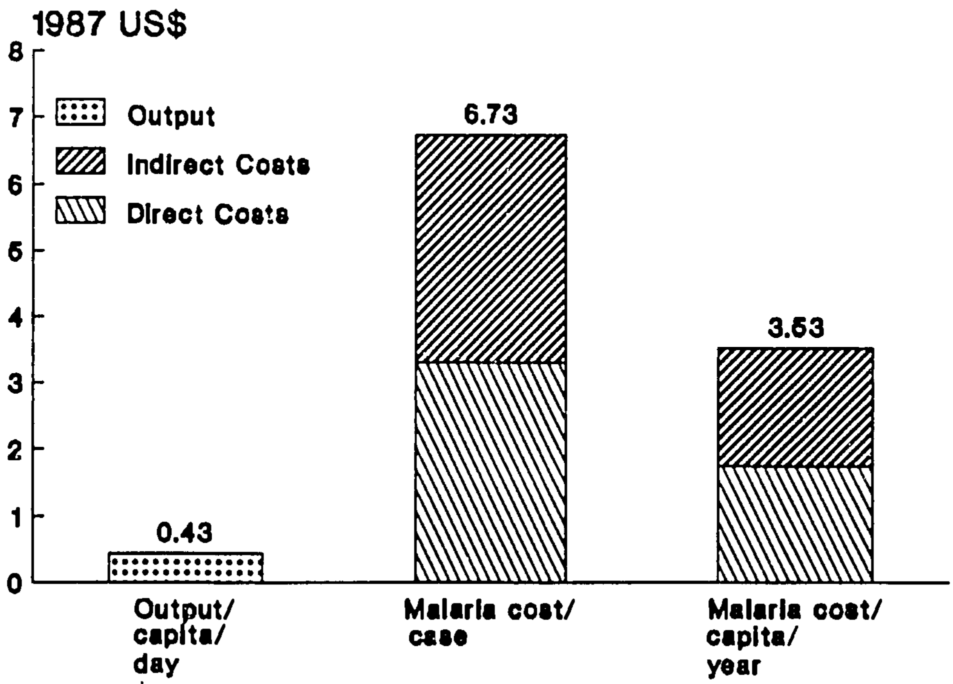


Fig. 12 Cost of Malaria in Rural Rwanda Projected 1995



Brazzaville, Congo, 1984

Brazzaville is the capital city of the People's Republic of Congo. In 1984, the year on which this case study is based, the population stood at just over half a million persons. Approximately 48 percent of the adult population was economically active, producing an average yearly household income of $1,280.

More men are economically active than women in Brazzaville, and of those more are salaried rather than independent workers. Therefore, the value of the time of a man in 1984 was $4.65 per day and that of a woman only $0.61 The average for all adults was $2.63 per day.

Data for the case were taken from published research reports. Little is readily available from government sources or routinely published epidemiological summaries.

There were an estimated 42,606 cases of malaria in Brazzaville in 1984, more than 90 percent of them among children. Approximately 92 percent of the cases were mild and treated at home with antimalarial drugs at a cost of $0.06 for a child and $0.40 for an adult. Severe cases incurred direct costs of $6.50 per day for the estimated six days of inpatient treatment required. Hospital costs are assumed to mirror the general pattern for sub-Saharan Africa, with higher costs in urban, centralized hospitals. Details of the calculations are contained in Annex A.4.

In 1984, the total cost of malaria was $0.74 per capita: $0.27 direct cost and $0.47 indirect cost (Fig. 13). During the same period, output was $1.43 per capita per day. Malaria costs represented less than one day of production. However, this relatively low cost per capita is a reflection of the similarly low overall incidence of malaria. Total cost per case was $8.77: $3.20 direct cost and $5.57 indirect cost. This can be taken as an indication of the burden of malaria on families that experience malaria morbidity. In these terms, malaria costs represent almost one week of average individual production, or 2.5 days of the average family income.

The impact of malaria was also projected for 1995. The population of Brazzaville was assumed to increase at an annual rate of 4.6 percent, the rate of urban population growth projected for Congo. Incidence of malaria cases was assumed to increase 7.3

Fig. 13 Cost of Malaria in Brazzaville 1984

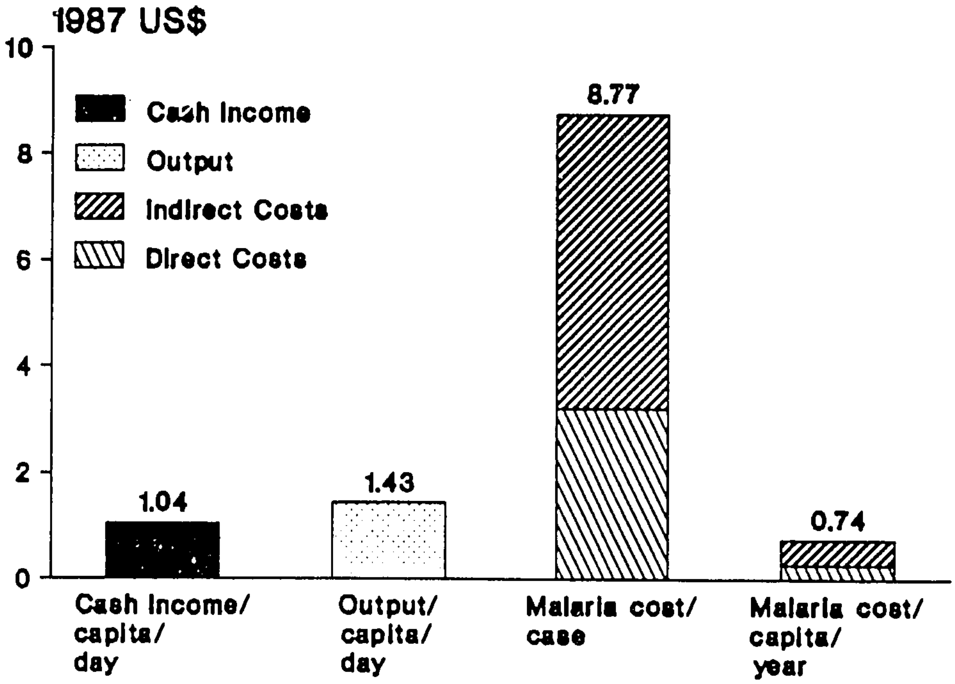
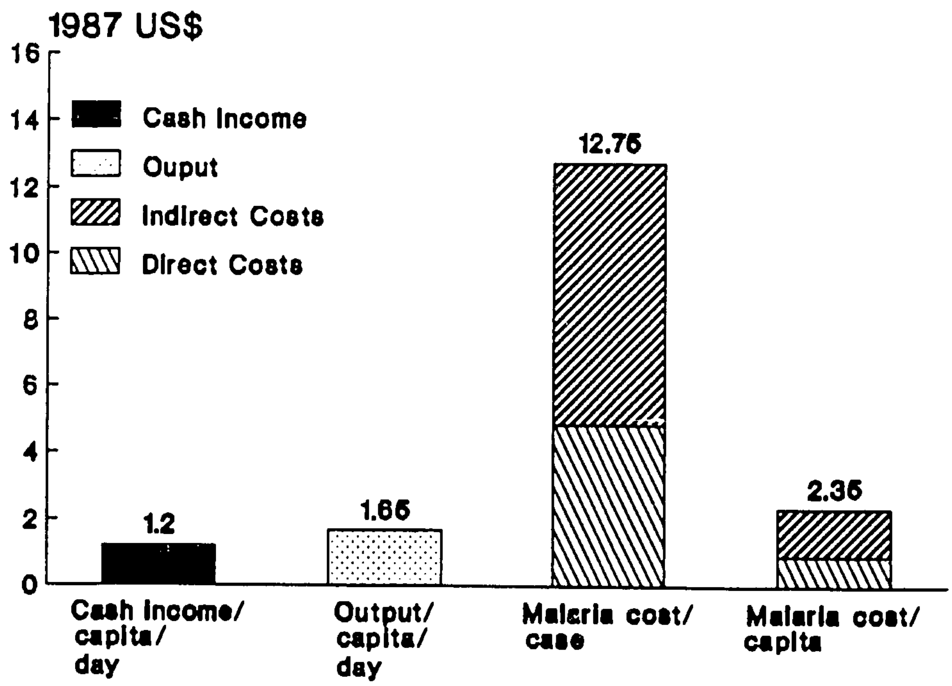


Fig. 14 Cost of Malaria in Brazzaville Projected 1995



percent annually. The proportion of severe cases was assumed to remain constant at eight percent and adult deaths are assumed to have risen to 10 percent of all deaths. The cost of drug treatment was assumed to double due to chloroquine resistance. Production was assumed to increase six percent per annum, the average rate of growth for the industrial and service sectors of the Congolese economy.

In 1995, the total cost of malaria is projected to equal $2.35 per capita: $0.89 direct cost and $1.46 indirect cost (Fig. 14). Output is expected to equal $1.65 per capita per day. Malaria costs, therefore, will represent approximately 1.5 days of production. Total cost per case will be $12.75: $4.84 direct and $7.90 indirect costs. Families experiencing malaria morbidity will spend four days of individual cash income ($1.20 per day) on treatment and expend more than seven days of individual production on a case of malaria. Details of the calculations are found in Annex A.4

Notes: Data on salary and wage income in Brazzaville in 1984 were obtained from the *1985 Annual Supplement to the Quarterly Economic Review of Congo, Gabon, Equatorial Guinea* (Economist Intelligence Unit 1985). The composition, size and gender breakdown of the working population in 1984 were determined from published reports (Devauges 1986). Household income figures for 1984 were obtained from the reports of Trape et al., which also provided much of the epidemiological information (Trape 1987). Costs of treatment were taken from the same report (Trape et al. 1987) and from expert opinion and experience of hospital costs in West Africa (Vogel 1988).

5. Expansion of the Case Studies to Sub-Saharan Africa

The lack of reliable reporting of malaria cases from most of sub-Saharan Africa hampers any estimation of the number of total cases in the region. Bruce-Chwatt (1985) estimated an annual 210 to 220 million infections for tropical Africa in a population of 388 million in 1980-82, a rate of 514 to 567 cases per 1000 population. However, not all infections will result in a clinical case of malaria. The WHO (1987) description of the world malaria situation in 1985 reports 5,636,000 cases from 1983 and an estimate of approximately 80 million clinical cases (90 million in 1988; WHO 1990) occurring every year in sub-Saharan Africa among a population of 400 million at risk. These estimates result in a rate of 200 to 225 per 1000 among the population at risk (88 percent of total). Clyde (1987) estimates the rate at 202.6 per 1000 population at risk.

In 1987, GDP of sub-Saharan Africa was $134,483 million, or $298 per capita. With economic growth at 2.3 percent per year and annual population growth at 3.1 percent, the per capita GDP would be expected to be even lower at $280 in 1995.

Using the average cost per case in the baseline year ($9.68) from the four case studies, applied to estimated cases per 1000 population at risk, the cost per capita of malaria is $1.72 in sub-Saharan Africa (see Annex A.6). The per capita cost of malaria in estimated to rise in 1995 to $3.16.

Overall, malaria in sub-Saharan Africa costs, by current estimates, about $800 million per year. This figure is projected to rise to over $1.8 billion by 1995. This projected cost can be compared to an estimated $63 million A.I.D. health budget for sub-Saharan Africa in fiscal 1991.

6. Conclusions and Recommendations

Major Findings

By several indicators, malaria is the foremost health problem in Africa. In Rwanda, where a dense network of health facilities has facilitated good disease reporting, malaria was by far the greatest cause of morbidity (174 cases per 1000 population) and mortality (0.2 deaths per 1000 population) in 1989 (Rwanda 1990). In Solenzo District, Burkina Faso, malaria accounted for more than 12 percent of all serious disease episodes and 23 percent of all deaths. Malaria is the leading cause of outpatient visits for the country as a whole. A classic study from Ghana assessed the burden of all illnesses in terms of potential days of life lost from illness and death combined, using 1975 data (Ghana Health Assessment Project Team 1981). Again, malaria ranked first, with an annual loss of 32 potential days per person.

This study compares the costs of malaria across four sites in Africa. It examines current data (1984 to 1989, depending on the site) and makes projections to 1995. Figure 15 shows the cost per case by site and the average for sub-Saharan Africa. Among the four sites, Rwanda has the lowest current cost per case ($5.60) and Mayo-Kebbi District, Chad has the highest ($12.80). The patterns reflect the health systems in these sites. In Rwanda, most care is provided by non-profit or government health centers that have relatively inexpensive operating costs. The case fatality rate is also low, which keeps indirect costs down.

The high cost in Chad is almost entirely due to indirect costs, reflecting the high mortality rate among child cases. In Solenzo District, Burkina Faso, the direct costs are elevated because most drugs are purchased in private pharmacies, where they are expensive, and travel distances and costs are substantial. Altogether, costs per case are remarkably consistent across the four sites. Despite the diversity of years, methods, and sources of data, cost per case varies only two-fold.

The average cost per malaria case for sub-Saharan Africa of $9.68 represents about 12 days of output (at $0.82 per day). The direct cost of $3.40 per case is equal to the entire annual public sector health expenditure in many African countries. That is, treatment of one case of malaria exhausts a person's entire share of his government's health resources.

Fig. 15 Malaria Cost per Case by Site

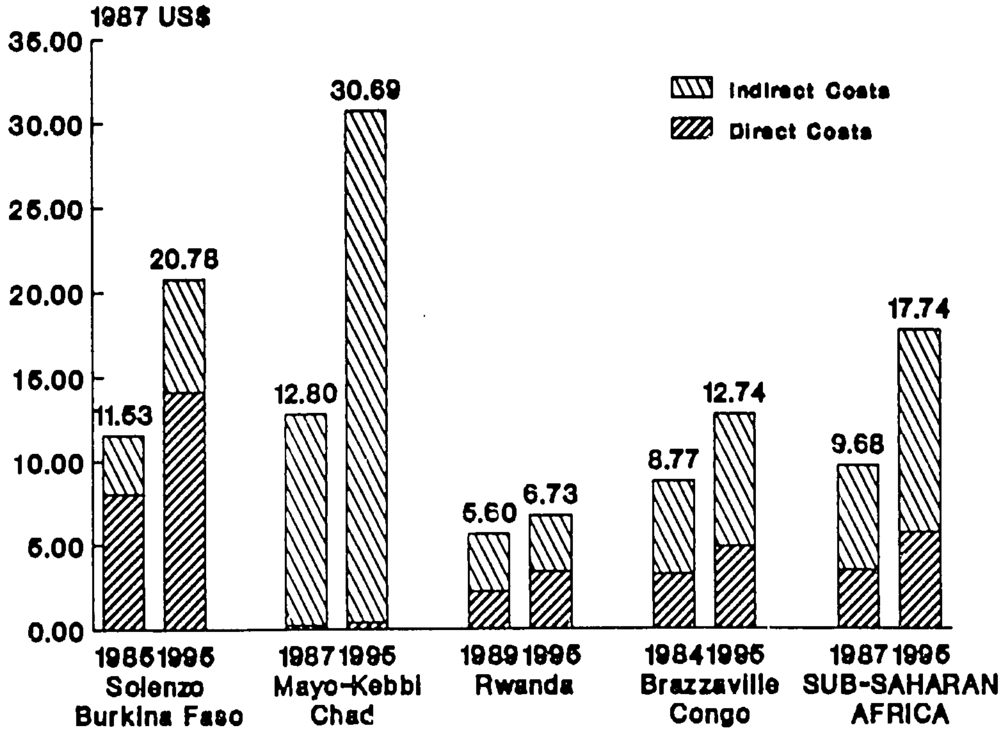
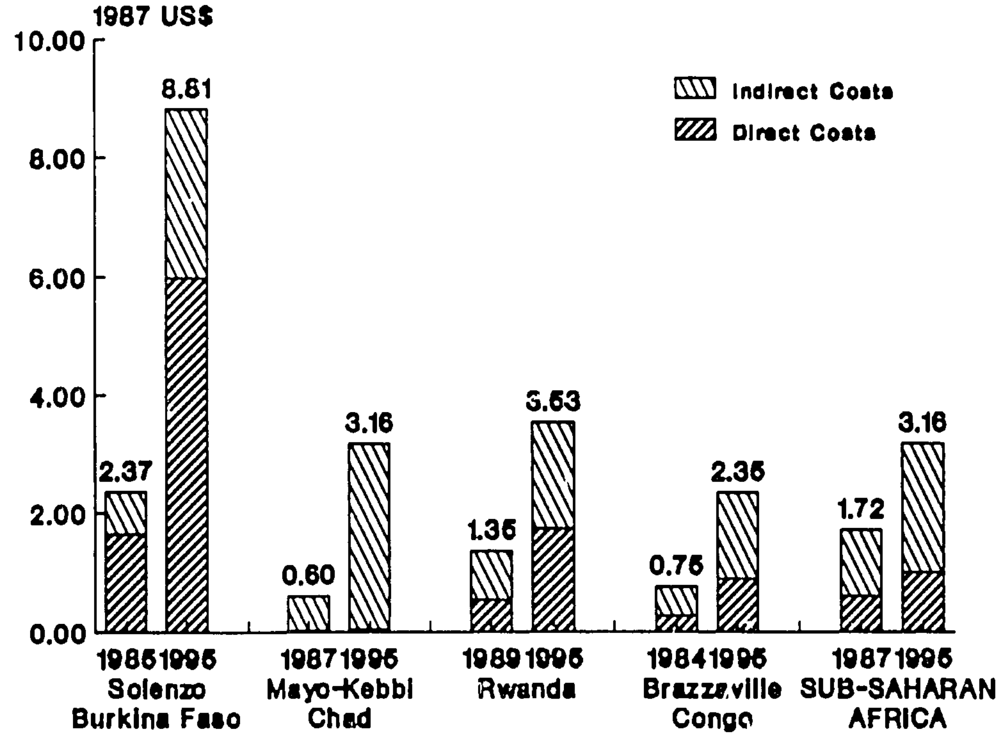


Fig. 16 Malaria Cost per Capita by Site



Projections to 1995 in Figure 15 show real cost per case (in constant 1987 dollars) rising in every site due to higher case fatality rates, more complex treatments (in the face of growing resistance), and, in some cases, a greater economic valuation of lost time. We project the greatest increase for Chad, where a moderate (2.6 percent) growth in the agricultural sector combined with a high (six percent) child malaria mortality rate creates substantial indirect costs. For sub-Saharan Africa as a whole, the projected cost per case is 23 days of output, valued at $0.77 per day.

Figure 16 shows cost per capita per year. This measure combines cost per case with incidence. Chad, which had the highest cost per case, has the lowest cost per capita due to a low incidence (50 cases per 1000 persons). Burkina Faso has the highest cost per capita due to the combination of a high cost per case ($11.53) and a high incidence (210 cases per 1000 persons). For sub-Saharan Africa as a whole, we project malaria cost per capita almost doubling as both incidence and cost per case increase. Overall, we project an annual cost of $3.16 per person.

Figure 17 shows output -- the value of goods and services -- per day by site. For national and international sites, we used GDP per capita as the measure of output. For the urban and provincial studies, for which GDP was not available, we used the value of production. Rural Chad, the poorest of the four sites, has the lowest current value ($0.12), while urban Brazzaville, the most developed, has the highest ($1.43). Trends were projected to 1995 based on the historical growth rate in the appropriate sector of the economy. Based on agricultural rates that substantially outstripped the population in Burkina Faso and Chad, we forecast substantial output growth rates for Solenzo District, Burkina Faso, and Mayo-Kebbi district, Chad. Similarly, growth in the industrial and service sectors in Congo kept ahead of population. In Rwanda, however, the 3.8 percent population growth rate has slightly outstripped the country's economic growth.

The projection for sub-Saharan Africa uses the most recent forecast from the IMF (1990) through 1991, and a trend forecast thereafter. This recent perspective shows that fewer resources will be available to address the malaria burden.

Figure 18 shows malaria cost as percent of output, both current and projected. The burden is greatest in the two sites that are entirely rural (Solenzo and Mayo-Kebbi), due to the combination of frequent and costly cases combined with low output. Conversely, urban Brazzaville, with relatively low incidence and substantial output, has the lowest share. For sub-Saharan Africa overall, the

Fig. 17 Output per Capita per Day by Site

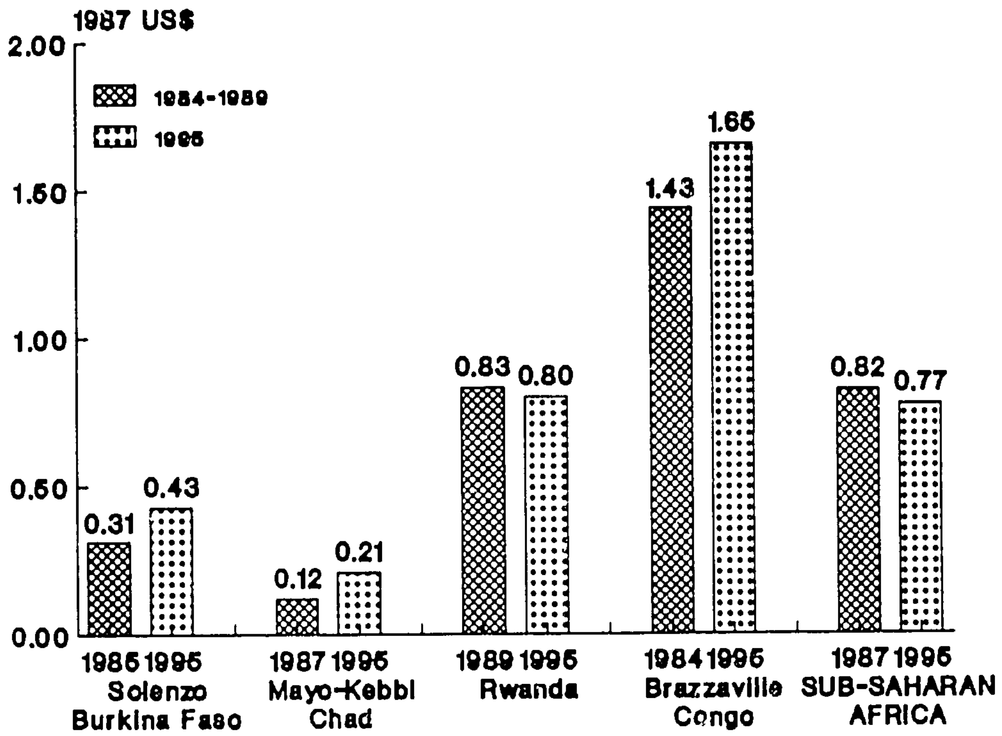
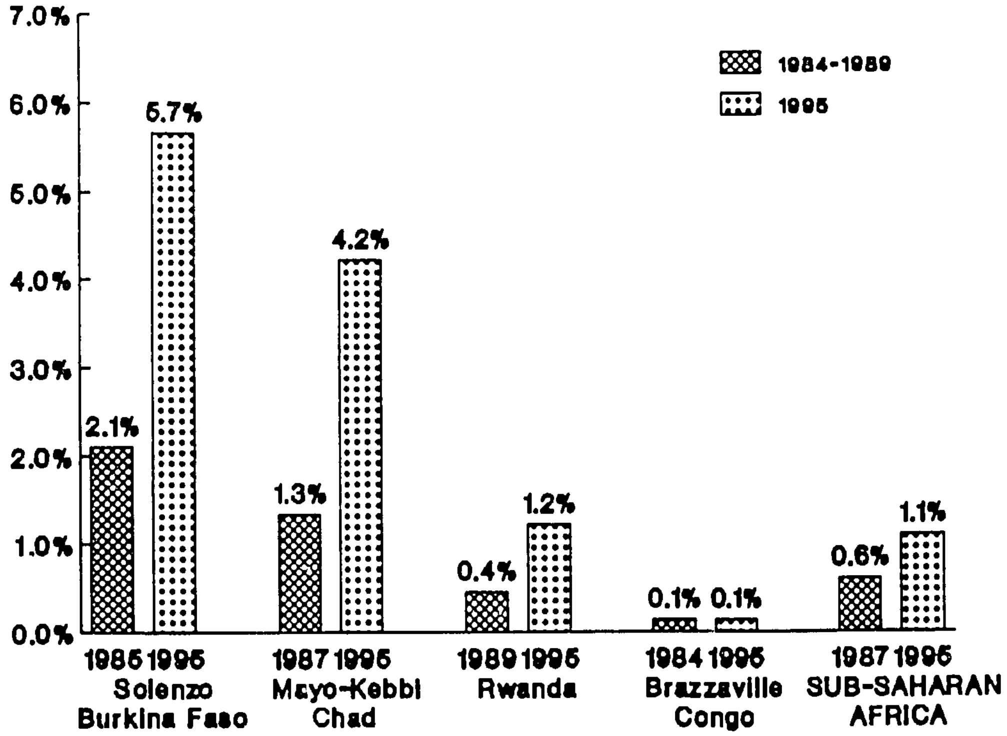


Fig. 18 Malaria Cost as % of Output by Site



current cost of malaria averages 0.6 percent of GDP and is projected to double to 1.1 percent by 1995. This share may appear modest, but it is a higher share of GDP than the entire budget of the Ministry of Health for one African country. For Rwanda in 1988, the MOH budget's share of GDP was only 0.9 percent (Rwanda 1989). Thus, the total direct and indirect cost for this one disease outstrip the public resources available for all diseases.

Expressed differently, the current burden of malaria in sub-Saharan Africa is equivalent to a loss of 2.1 days of output for every person. By 1995, it will probably be 4.1 days.

Implications

The economic cost of malaria is an appreciable, and rapidly rising, burden. Malaria has a substantial impact on African health care systems. It was the greatest cause of outpatient visits in both Rwanda and Burkina Faso (Rwanda 1990). Drugs tend to be an especially scarce resource in African health systems. For example, in 1986, only 60 percent of common drugs were available in government health centers in Rwanda (Shepard et al. 1987). In 1989, financial constraints forced the Ministry of Health to cut its drug budget by 42 percent, which exacerbated the problem. In this situation, when more drugs are needed for malaria, fewer can be purchased for other readily treated conditions, such as worms, respiratory infections and diarrhea.

Effective control measures would thus have a substantial payoff. Simply averting growth in the cost of malaria as a share of output would save 0.5 percentage points of GDP. That is, the burden would be maintained at 0.6 percent of GDP, rather than 1.1 percent as forecast for 1995. If the burden of malaria could be cut -- through reducing incidence, severity, or treatment costs -- a greater share of GDP would be saved. If the currently burden were reduced by somewhat more than a half, the future economic burden could be a full percentage point less than the 1.1 percent of GDP projected for 1995 for sub-Saharan Africa.

The choice of strategies most likely to control malaria in Africa is a complex subject. The Institute of Medicine has already instituted a worldwide study on strategies to control malaria, and the American Association for the Advancement of Science is planning a study specifically addressing malaria in Africa. One reason for the difficulty in controlling malaria is the danger that a successful control program would reduce immunity to malaria among adults and render them liable to far more serious attacks in the future. In general, the WHO recommends better case management (prompt diagnosis and treatment with antimalarial drugs) as the main current strategy (WHO 1986).

Bed nets impregnated with permethrin proved to be an effective control strategy in a randomized trial in the Gambia, and trials are underway in several other countries (MacCormack et al. 1989). In the Gambian study, the insecticide-impregnated bed nets reduced clinical attacks in children by 63 percent compared to unimpregnated nets. The authors estimated the cost of bed nets and antimalarial drugs as $1.24 per child per year.

Our study of economic costs of illness would allow cost-benefit and cost-effectiveness studies of control measures. For example, suppose the Gambian intervention were applied to an average area in sub-Saharan Africa. If children were half of the population, the per capita cost of the control measure in the Gambian study would be $0.62 per year. The per capita economic cost of malaria is $1.72 currently (1987) and $3.16 projected for 1995. Assuming the projected economic benefits were proportional to the reduction in incidence, they would be $1.08 and $1.99, respectively. Thus, for every one dollar spent on bed nets and antimalarial treatment, the short-run savings would be about $1.75 currently (1.08 divided by 0.62) and $3.20 (1.99 divided by 0.62) projected for 1995.

A more careful study would be necessary to examine the validity of the assumptions and consider possible long-run effects on immunity. Oth r measures recommended by WHO to reduce transmission, such as window screens, protective clothing, and environmental controls, could also be evaluated. Likewise, strategies to improve case management and access to antimalarial drugs could be assessed through cost-benefit evaluations.

We recommend operations research studies to evaluate the costs and effectiveness of improved laboratory services, better supervision, community pharmacies, and training of health workers towards reducing the incidence and severity of clinical malaria. It is useful to perform a number of such studies so that several interventions, across multiple sites, can be evaluated. The results of such studies, combined with the economic data presented here, can help guide decisions on expenditures to strengthen case management. For an average area in sub-Saharan Africa, an expenditure up to $0.20 per capita is economically justified if it achieves only a 10 percent reduction in the cost of malaria.

Finally, this study was limited to existing data. Our literature review found no microeconomic empirical study set in Africa of the effect of malaria on production using an appropriate measure of clinical cases. Empirical research on this subject deserves high priority. To be most cost-effective, it would be useful to perform the study in conjunction with research on household production and consumption behavior to minimize the amount of new data collection.

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ANNEXES

Annex A.1 Calculations for Solenzo Case

Methodology used for the Solenzo Case: an example

The numbers of mild and severe cases were taken from expansions of data from the household survey and multiplied by the duration of each case. Child cases were adjusted to the amount of adult time lost to work by attending the sick child.

1. (Adult cases + (Child cases x %adult time loss)) x duration/case = Total days lost from work

   The total days of lost work are valued by the value of time in each season.

2. Total days lost x Value of time = Total output loss

   The marginal productivity of an adult is valued as the total output of the community divided equally among all adults.

3. (Total work days x Value of time) ÷ Adult population = Marginal product per adult

   The present value of the lifetime earnings of a child of one year is the marginal production per year multiplied by a factor that discounts future earnings applied to a life table from Ivory Coast.

4. Marginal product x 2.82 = Present value of lifetime earnings at one year

   The indirect costs of malaria are equal to the sum of the productivity loss from morbidity and the lifetime earnings loss from child mortality.

5. (Present value of lifetime earnings x child deaths) + Total output loss = Indirect cost of malaria

   Direct costs of malaria are equal to the average cost per type of case (determined from the household survey) multiplied by the number of cases of that type.

6. Cost per case x Cases = Direct cost of malaria

   All money values determined in 1985 are adjusted to 1987 US$ by multiplying them by the ratio of the deflator indices of 1987 and 1985 and dividing this number by the US$ exchange rate in 1987.

7. (1985 cost x (Deflator 1987 ÷ Deflator 1985)) ÷ Exchange rate 1987 = 1985 cost in 1987 US$

   The cost per case is determined by dividing the cost of malaria (either direct or indirect) by the total number of cases.

8. Total cost of malaria ÷ Total cases = Cost per case

   Similarly, the cost per capita is the cost divided by the total population.

9. Total cost of malaria ÷ Total population = Cost per capita

   The cash income per capita is equal to the cash income from each season totalled for the year, divided by the total population.

10. (Output in each season x %Output converted to cash in the season) ÷ Total population = Cash income per capita

    Projections of the economic growth are made by applying the stated growth rate to the number of years from the base year to 1995 and multiplying this by the baseline output.

11. Total output baseline x (1+Growth Rate)^Years = Total output 1995

    Projections of population size for 1995 are calculated in the same way.

12. Population baseline x (1+Growth Rate)^Years = Population 1995

    The growth in malaria incidence is applied to the baseline incidence.

13. Incidence baseline x (1+Growth Rate)^Years = Incidence 1995.

In the case of Rwanda, the growth rate is applied to the baseline number of cases for each facility.

Growth rates for the rural agricultural sector are calculated from the national GDP growth rate, the industrial and service sector growth rate, and the %age of the GDP in each sector.

14. Agriculture growth rate = [GDP growth rate - (Industrial & services sector growth rate x %Industrial & services sector)] + %Agricultural sector

Rural population growth rates are calculated in a like manner.

15. Rural population growth rate = [National population growth rate - (Urban population growth rate x %Urban population)] + %Rural population

Table A.1.1 Solenzo District Production, 1985

Solenzo Medical District
Economic Loss in an Agricultural Community
1985 (1987 $US)

	Maintenance (Jan-Feb)	Economic Periods Cash crop (Mar-Apr)	Food crop (May-Dec)	Total
Daily income	$0.28	$1.09	$0.55	$0.60
Mild cases adult	45	36	240	321
Mild cases child	126	100	672	899
Severe cases adult	10	8	53	71
Severe cases child	5	4	27	36
Total cases	187	148	992	1326
Child population	3118	3118	3118	3118
Working population	3324	3324	3324	3324
Population	6442	6442	6442	6442
Annual output/adult	$16	$67	$135	$218
Total annual output	$54,105	$221,133	$449,351	$724,590
Annual output/capita	$8	$34	$70	$112
Adult days(WD)	196,120	202,768	814,398	1,213,286
WD loss/mild case	1	1	1	1
WD loss/adult severe	5	5	5	5
WD loss/child severe	1.67	1.67	1.67	1.67
Total WD loss	230	182	1223	1634
Total output loss	$63	$198	$675	$976
Per ill person	$0.34	$1.34	$0.68	$0.74
Per worker	$0.02	$0.06	$0.20	$0.29
Per capita	$0.01	$0.03	$0.10	$0.15

Conversion factor 1985 (CFA Francs per $US)	275
Conversion factor 1987 (CFA Francs per $US)	300.54
Domestic price deflator index 1987/85	0.973

Assumptions:

1. All adults economically active
2. Income applies to 365 days per year
3. Adult productivity loss is 1/3 for 3 days in mild illness
4. Adult time loss is 1 day in child mild illness
5. Adult time loss is 5 days in severe adult illness
6. Adult time loss is 1/3 for days in severe child illness

Table A.1.2 Solenzo: Direct and Indirect Costs, 1985

Solenzo Medical District
Direct & Indirect Costs of Malaria, 1985
(1987 $US)

Life expectancy	47.4
Output/year/ working person	218
PV life earnings	$615
Child deaths	6
Cost of child deaths	$3,688
Direct cost/death	$16.27
Direct cost/mild case	$7.77
Direct cost/severe case	$9.82
Total direct cost	$10,627
Output loss	$976
All malaria costs	$15,291

Assumptions:
1. Ivory Coast life tables
2. PV is 2.82 times output/year (Shepard et al. 1986)

Table A.1.3 Economic Impact of Malaria in Solenzo, 1985

Economic Impact of Malaria in Solenzo 1985 (1987 $US)

Direct Costs	$10,627
Indirect Costs	$4,664
Total costs	**$15,291**
Cost/case	
Direct	$8.01
Indirect	$3.52
Total	$11.53
Cost/capita	
Direct	$1.65
Indirect	$0.72
Total	$2.37
Cost/adult	
Direct	$3.20
Indirect	$1.40
Total	$4.60
Cash income/day/capita	$0.12
Output/day/capita	$0.31

Assumptions:

1. Agricultural output is 15% converted to cash
2. Cash crop income is 100% converted to cash
3. Maintenance output is 0% converted to cash

Table A.1.4 Production in Solenzo, 1995

Solenzo Medical District
Projected Economic Loss in an Agricultural Community
1995 (1987 $US)
Economic Periods

	Maintenance (Jan–Feb)	Cash crop (Mar–Apr)	Food crop (May–Dec)	Total
Mild cases adult	121	96	646	863
Mild cases child	340	269	1809	2418
Severe cases adult	27	21	143	191
Severe cases child	13	11	71	96
Total cases	502	397	2669	3568
Child population	4070	4070	4070	4070
Working population	4339	4339	4339	4339
Population	8409	8409	8409	8409
Total annual output	$97,812	$399,767	$812,343	$1,309,922
Annual output/adult	$23	$92	$187	$302
Annual output/capita	$12	$48	$97	$156
Daily output/adult	$0.38	$1.51	$0.76	$0.83
Adult days (WD)	255,992	264,670	1,063,019	1,583,681
WD loss/mild case	1	1	1	1
WD loss/adult severe	5	5	5	5
WD loss/child severe	1.67	1.67	1.67	1.67
Total WD loss	618	489	3288	4396
Per ill person	$0.47	$1.86	$0.94	$1.02
Per worker	$0.05	$0.17	$0.58	$0.84
Per capital	$0.3	$0.09	$0.30	$0.43
Rural population annual growth rate				
Annual increase in cases				
Annual growth of real GDP				

Assumptions:
1. All adults economically active
2. Income applies to 365 days per year
3. Adult productivity loss is 1/3 for 3 days in mild illness
4. Adult time loss is 1 day in child mild illness
5. Adult time loss is 5 days in severe adult illness
6. Adult time loss is 1/3 for 5 days in severe child illness
7. GDP growth applies to all three seasons
8. Population growth rates apply to adults and children

Table A.1.5 Solenzo: Direct and Indirect Costs of Malaria 1995

Solenzo District:
Projected Direct & Indirect Costs of Malaria, 1995
(1987 $US)

Work life(years)	30
Output/year/working person	$302
PV life earnings 1 year	$851
Child deaths	16
PV earnings 35 years	$3,593
Adult deaths	2
Cost of Mortality	$20,181
Direct cost/death	$28.47
Direct cost/mild case	$13.60
Direct cost/severe case	$18.17
Total Direct Cost	$50,299
Output Loss	$3,636
All Malaria Costs	$74,116

Assumptions:

1. Ivory Coast life tables
2. Child deaths increase 10.4 % annually
3. Drugs are 75 % of direct cost of mild cases
4. Drugs are 85 % of direct cost of severe cases
5. Drugs are 75 % of direct cost of fatal cases
6. Cost of drugs will double due to resistance
7. Adult death 10 % of total
8. PV child earnings is 2.82 times output/year (Shepard et al. 1986)
9. PV adult earning is 11.9 times output/year (10 % discount for 30 years)

Table A.1.6 Economic Impact of Malaria in Solenzo 1995

Projected Economic Impact of Malaria in Solenzo 1995 (1987 $US)

Direct Costs	$50,299
Indirect Costs	$23,817
Total Costs	$74,116
Cost/case	
Direct	$14.10
Indirect	$6.68
Total	$20.77
Cost/capita	
Direct	$5.98
Indirect	$2.83
Total	$8.81
Cost/adult	
Direct	$11.59
Indirect	$5.49
Total	$17.08
Cash income/day/capita	$0.17
Output/day/capita	$0.43

Assumptions:

1. Agricultural output is 15 % converted to cash
2. Cash crop income is 100 % converted to cash
3. Maintenance output is 0 % converted to cash

Annex A.2. Calculations for Mayo-Kebbi Case

Table A.2.1 Production in Mayo-Kebbi 1987

Production in Mayo-Kebbi District, Chad 1987

Population	650,179
%Children	42%
Child population	273,075
Adult population	377,104
GDP/capita	$185
GDP/adult/year	$319
Income/capita/year	$45.27
Cash income/capita/year	$24.72
Marginal productivity/adult/year	$78.05
PV earnings at 1 year	$220.10
PV earnings at 35 years	$928.77
Time loss for child case (days)	2
Time loss for adult case (days)	3.5
Conversion rate 1987	300.54
Conversion rate 1985	449.26
Domestic price deflator 1987/85	1.03

Assumptions:
1. PV child earnings and 2.82 times productivity/year (Shepard et al. 1986)
2. PV adult earnings is discounted 10 % for 30 years

Table A.2.2 Mayo-Kebbi: Direct and Indirect Costs of Malaria 1987

Mayo-Kebbi District, Chad, 1987
Direct and Indirect Costs of Malaria

Child cases	27,878
%Deaths	6%
Child deaths	1,673
PV earnings 1 yr.	$220.10
Cost of child mortality	**$368,149.00**
Time loss/child case	$0.43
Total time loss	$11,922.00
Treatment cost/child case	$0.07
Travel cost/child case	$0.10
Total direct cost	$4,790.00
Cost of child morbidity	$16,713.00
Adult cases	2,424.00
Adult deaths	0
PV earnings 35 yr.	$929.00
Cost of adult mortality	**$0**
Time loss/adult case	$0.75
Total time loss	$1,814.00
Treatment cost/adult case	$0.20
Travel cost/adult case	$0.31
Total direct cost	$1,250.00
Cost of adult morbidity	$3,064.00
Total cost of malaria	**$387,925.00**

Assumptions:

1. Travel costs are 56 % of total direct cost per case.

Table A.2.3 Economic Impact of Malaria in Mayo-Kebbi, 1987

Mayo-Kebbi District, Chad
Cost of Malaria, 1987

Population	650,179
Cases	30,302
Direct Cost	$6,040.00
Indirect Cost	$381,885.00
Total Cost	$387,925.00
Output/capita/day	$0.12
Cash income/capita/day	$0.07
Malaria cost/case	
Direct	$0.20
Indirect	$12.60
Total	$12.80
Malaria cost/capita	
Direct	$0.01
Indirect	$0.59
Total	$0.60

Table A.2.4 Production In Mayo-Kebbi, 1995

Production In Mayo-Kebbi District, Chad
Projection 1995

Population	671,278
%Children	42%
Child population	281,937
Adult population	389,341
GDP/capita	$275.00
GDP/adult/year	$475.00
Income/capita/year	$74.92
Cash income/capita/year	$40.91
Marginal productivity/adult/year	$129.17
PV earnings at 1 year	$364.26
PV earnings at 35 years	$1,537.11
Time loss for child case (days)	2
Time loss for adult case (days)	3.5
Annual agriculture sector growth	2.6%
Annual rural population growth	0.4%
Annual growth of income/capita	6.5%
Annual growth rate of incidence	10.4%

Table A.2.5 Mayo-Kebbi: Direct and Indirect Costs of Malaria, 1995

Mayo-Kebbi District, Chad
Direct and Indirect Costs of Malaria
Projection 1995

Attacks/child	0.23
Child cases	63,523
%Deaths	6 %
Child deaths	3,811
PV earnings 1 yr.	$364.26
Cost of child mortality	**$1,388,318.00**
Time loss/child case	$0.71
Total time loss	$44,960.00
Treatment cost/child case	$0.14
Travel cost/child case	$0.21
Total direct cost	$21,830.00
Cost of child morbidity	**$66,790.00**
Attacks/adult	0.01
Adult cases	5,499
Adult deaths	423
PV earnings 35 yr.	$1,537.00
Cost of adult mortality	**$650,945.00**
Time loss/adult case	$1.24
Total time loss	$6,811.00
Treatment cost/adult case	$0.41
Travel cost/adult case	$0.62
Total direct cost	$5,669.00
Cost of adult morbidity	$12,480.00
Total cost of malaria	**$2,118,533.00**

Assumptions:

1. 1987 attacks per child were 0.1021
2. No change in child case fatality rate
3. Adult deaths increase to 10 % of total
4. Costs of drugs double due to resistance
5. Travel cost 66 % of direct cost

Table A.2.6 Economic Impact of Malaria in Mayo-Kebbi, 1995

Mayo-Kebbi District, Chad
Cost of Malaria
Projection 1995

Population	671,278
Cases	69,022
Direct cost	$27,499.00
Indirect cost	$2,091,034.00
Total cost	$2,118,533.00
Output/capita/day	$0.21
Cash income/capita/day	$0.11
Malaria cost/case	
Direct	$0.40
Indirect	$30.30
Total	$30.69
Malaria cost/capita	
Direct	$0.04
Indirect	$3.12
Total	$3.16

Annex A.3 Calculations for Rwanda

Table A.3.1 Malaria Cases and Deaths by Facility 1989

Treatment Costs of Malaria in Service Facilities
Rwanda 1989 (1987 $US)

	Facility	Cases	Public cases	Cost/day average	Cost/day malaria	Days/case average	Days/case malaria	Cost/ case	Public cost	Total cost
NUTRITION CENTER	Ambulatory	64683	2209	$1.16	$1.16	1.00	1.00	$1.16	$2,552	$74,712
	Inpatient	4827	76	$3.51	$2.32	5.79	2.80	$6.49	$493	$31,335
	Deaths	57								
HEALTH CENTER	Ambulatory	824490	510637	$1.31	$1.31	1.00	1.00	$1.31	$668,860	$1,079,962
	Inpatient	69921	37127	$3.99	$2.63	4.20	2.80	$7.37	$273,695	$515,448
	Deaths	839								
DISPEN- SARY	Ambulatory	208151	158810	$1.16	$1.16	1.00	1.00	$1.16	$183,434	$240,426
	Inpatient	6727	4918	$3.51	$2.32	3.77	2.80	$6.49	$31,926	$43,669
	Deaths	87								
HOSPITAL	Ambulatory	179081	108355	$2.32	$2.32	1.00	1.00	$2.32	$251,602	$415,829
	Inpatient	30319	19737	$7.03	$4.64	6.03	6.03	$27.96	$551,855	$847,732
	Deaths	745								
INFIRMARY	Ambulatory	61806	46945	$1.31	$1.31	1.00	1.00	$1.31	$61,491	$80,957
	Inpatient	1821	1804	$3.99	$2.63	4.34	4.34	$11.43	$20,613	$20,807
	Deaths	4								
SANATORIUM	Ambulatory	3387	3387	$2.32	$2.32	1.00	1.00	$2.32	$7,865	$7,865
	Inpatient	0	0	$7.03	$4.64	6.03	6.03	$27.96	$0	$0
Total cases			1,455,213							
Total deaths			1732							
Total cost									$3,358,743	
Total public cost										$2,054,386

Conversion factor 1989 (FRW per $US)	78
Conversion factor 1987 (FRW per $US)	79.67
Domestic price deflator index 1987/89	0.95
Conversion factor 1986 (FRW per $US)	87.64

Assumptions:
1. Costs of public applied to other facilities
2. Nutrition posts and infirmaries have costs as in dispensaries
3. LOS for nutrition centers is as in infirmaries
4. Health centers subsume "posts"
5. Sanatorium costs are as for hospitals
6. Malaria costs in hospital are 2/3 the average medical admission

Table A.3.2 Rwanda: Indirect Costs of Malaria, 1989

Rwanda 1989
Indirect Costs of (Malaria)
(1987 $US)

Income	$435
%Adults	
Shadow wage rate	0.85
Marginal product/ active adult	$369
PV earnings at 1yr	$1,042
All malaria deaths	1732
Child deaths(%)	90%
#Child deaths	1559
Cost of child mortality	**$1,624,191**
PV earnings at 35 yr	$4,396
Adult deaths(%)	10%
#Adult deaths	173
Cost of adult mortality	**$761,443**
Shadow wage/day/adult	$1.01
Duration illness	3.5
Total cases	1,712,015
Adults cases (%)	40%
#Adult cases	684806
Cost of adult morbidity	**$2,425,968**
Child cases (%)	60%
#Child cases	1,027,209
Adult time/case (days)	1
Cost of child morbidity	**$1,039,701**
Total indirect costs	**$5,851,302**

Assumptions:
1. 90 % of mortality is child
2. 60 % of cases are child
3. Child case uses 1 day adult time
4. Adult case uses 3.5 days of adult time
5. All adults economically active
6. Wage applies 365 days per year
7. Ivory Coast life tables
8. Adult deaths at 35 years
9. Loss of working life/ adult death is 30 years
10.Reported cases are 85 % of all cases

Table A.3.3 Rwanda: Direct Costs Outside Facilities, 1989

Rwanda 1989
Cost of Non-facility
Treatment of Malaria Cases
(1987 $US)

Facility cases	1,455,213
%Treated at facilities	85%
Total Cases	1,712,015
%Treated at pharmacies	10%
%No modern treatment	5%
Pharmacy cost/case	$1.00
Traditional cost/case	$2.50
Pharmacy costs	$171,202
Traditional costs	$214,002
Total	$385,203

Table A.3.4 Rwanda: Summary of Costs, 1989

Rwanda 1989
Costs of Malaria
(1987 $US)

Direct treatment	
Facility-based	$3,358,743
Other-based	$385,203
Subtotal	$3,743,946
Indirect	
Child mortality	$1,624,191
Adult mortality	$761,443
Child morbidity	$1,039,701
Adult morbidity	$2,425,968
Subtotal	$5,851,302
Total	$9,595,248

Table A.3.5 Economic Impact of Malaria in Rwanda, 1989

Economic Impact of Malaria in Rwanda 1989
(1987 $US)

Population	7,083,110
MOH Budget	$11,334,222
GDP/capita	$303
Cases	1,712,015
Cost of malaria/case	
Direct	$2.19
Indirect	$3.42
Total	$5.60
Cost of malaria/capita	
Direct	$0.53
Indirect	$0.83
Total	$1.35
Daily rural cash income/capita	$.09
Daily rural output/capita	$0.41
Health expenditure/capita Rural	$3.66
MOH Budget/capita	$1.60
GDP/capita/day	$0.83

Table A.3.6 Rwanda: Malaria Cases and Deaths by Facility, 1995
Rwanda Treatment Costs of Malaria in Service Facilities, 1995 (1987 $US)
All Malaria and Fever Cases

	Facility	Cases	Public cases	Cost/day average	Cost/day malaria	Days/case average	Days/case malaria	Cost/ case	Public cost	Total Cost
NUTRITION CENTER	Ambulatory	169162	5777	$2.07	$2.07	1.00	1.00	$2.07	$11,979	$350,767
	Inpatient	12624	199	$6.31	$4.16	5.79	2.80	$11.65	$2,316	$147,115
	Deaths	149								
HEALTH CENTER	Ambulatory	2156247	1335443	$1.95	$1.95	1.00	1.00	$1.95	$2,603,389	$4,203,511
	Inpatient	182861	97096	$5.94	$3.92	4.20	2.80	$10.97	$1,065,297	$2,006,266
	Deaths	2194								
DISPEN-SARY	Ambulatory	544367	415328	$2.07	$2.07	1.00	1.00	$2.07	$861,204	$1,128,773
	Inpatient	17593	12862	$6.31	$4.16	3.77	2.80	$11.65	$149,889	$205,023
	Deaths	228								
HOSPITAL	Ambulatory	468341	283375	$3.40	$3.40	1.00	1.00	$3.40	$962,788	$1,591,224
	Inpatient	79292	51617	$10.28	$6.78	6.03	6.03	$40.91	$2,111,746	$3,243,959
	Deaths	1948								
INFIRMARY	Ambulatory	161638	122773	$2.35	$2.35	1.00	1.00	$2.35	$288,694	$380,084
	Inpatient	4762	4718	$7.16	$4.73	4.34	4.34	$20.51	$96,777	$97,689
	Deaths	10								
SANATORIUM	Ambulatory	8858	8858	$3.40	$3.40	1.00	1.00	$3.40	$30,095	$30,095
	Inpatient	0	0	$10.28	$6.78	6.03	6.03	$40.91	$0	$0
Total cases		3805745								
Total deaths		4530								
Total cost									$13,384,506	
Total public cost										$8,184,175

Conversion factor 1989 (FRW per $US)	78	Conversion factor 1986 (FRW per $US)	87.64
Conversion factor 1987 (FRW per $US)	79.67	Annual increase in cases	21.2%
Domestic price deflator index 1987/89	0.95	Annual population increase	3.8%

Assumptions:

1. Costs of public applied to other facilities
2. Nutrition posts and infirmaries have costs as in dispensaries
3. LOS for nutrition centers is as in infirmaries
4. Health centers subsume "posts"
5. Sanatorium costs are as for hospitals
6. Malaria costs in hospital are 2/3 the average medical admission
7. Annual increase 21.2 % in malaria cases
8. Increase applies uniformly across facilities
9. Increase applies to deaths also
10. Drug costs will double due to chloroquine resistance
11. Drugs make up 21 % of Health Center costs, 18 % of Hospital costs, and 32 % of Dispensary costs
12. Likely 100 % devaluation of the FRW will double drug and supply costs
13. Drugs and supplies together make up 23 % of Health Center costs, 24 % of Hospital costs, and 36 % of Dispensary costs

Table A.3.7 Rwanda: Indirect Costs of Malaria, 1995

Rwanda Indirect Costs of Malaria
All Fever and Malaria, 1995
(1987 $US)

Annual income/adult	$435
%Adults	
Shadow wage rate	0.85
Marginal product/ active adult	$369
PV earnings at 1yr	$1,042
All malaria deaths	4530
Child deaths(%)	90%
#Child deaths	4077
Cost of child mortality	**$4,247,665**
PV earnings at 35 yr	$4,396
Adult deaths(%)	10%
#Adult deaths	453
Cost of adult mortality	**$1,991,362**
Shadow wage/day/adult	$1.01
Duration illness	3.5
Total cases	4,477,347
Adults cases(%)	40%
#Adult cases	1,790,939
Cost of adult morbidity	$6,344,512
Child cases(%)	60%
#Child cases	2,686,408
Adult time/case (days)	1
Cost of child morbidity	$2,719,076
Total indirect costs	**$15,302,615**

Assumptions:
1. 90 % of mortality is child
2. 60 % of cases are child
3. Child cases uses 1 day adult time
4. Adult case uses 3.5 days of adult time
5. All adults economically active
6. Wage applies 365 days per year
7. Ivory Coast life tables
8. Adult deaths at 35 years
9. Loss of working life/adult death is 30 years
10. Reported cases are 85% of all cases
11. Wage unchaged from 1989

Table A.3.8 Rwanda: Summary of Direct and Indirect Costs, 1995

Rwanda Costs of Malaria
All Fever and Malaria, 1995
(1987 $US)

Direct treatment	
Facility-based	$13,384,506
Other-based	$1,455,138
Subtotal	$14,839,644
Indirect	
Child mortality	$4,247,665
Adult mortality	$1,991,362
Child morbidity	$2,719,076
Adult morbidity	$6,344,512
Subtotal	$15,302,615
Total	**$30,142,258**

Table A.3.9 Economic Impact of Malaria in Rwanda, 1995

Cost of Malaria In Rwanda
All Fever and Malaria
(1987 $US)

Population	8,535,142
MoH Budget	$12,513,897
GDP/capita	$290
Cases	4,477,347
Cost of malaria/case	
Direct	$3.31
Indirect	$3.42
Total	**$6.73**
Cost of malaria per capita	
Direct	$1.74
Indirect	$1.79
Total	**$3.53**
MoH Budget/capita	$1.47
GDP/capita/day	$0.80
Output/capita/day	
Rural	$0.43

Assumptions:

1. Annual population growth 3.8 %
2. MoH Budget annual growth 2 %
3. Annual GDP growth 2.4 %
4. Agricultural growth rate 1.1 %
5. Rural population growth 3.5 %
6. Rural output/capita growth .98 %

Annex A.4 Calculations for Brazzaville Case

Table A.4.1 Production in Brazzaville, 1984
Brazzaville Income and Production
($US 1987)

	Males>15	Females>15	Total
Population	135,773	135,773	271,546
%Active	74.3%	21.8%	48.1%
#Active	100879	29599	130478
%Independent	27.5%	72.1%	37.6%
%Salaried	72.5%	27.9%	62.4%
Wage active independent	$707		
Wage active salaried	$3,698		
Wage/adult/yr	$2,137	$336	$1,236
Wage/adult/day	$5.85	$0.92	$3.39
Shadow wage rate independent	0.31		
Shadow wage rate salaried	0.83		
Income/adult/yr	$1,698	$221	$960
Income/adult/day	$4.65	$0.61	$2.63
Shadow wage rate all	0.79	0.66	0.73
Total daily production	$714,009		
Factor with discount and risks	2.82		
PV earnings at 1yr	$2,706		

Conversion factor 1984(CFA Francs per $US)	436.96
Conversion factor 1987(CFA Francs per $US)	300.54
Domestic price deflator(1987/84)	0.744654

Table A.4.2 Brazzaville: Direct and Indirect Costs of Malaria, 1984

Brazzaville 1984
Direct and Indirect Costs of Malaria
($US 1987)

	Unit	Total
Total population		500,761
Child population		229,215
Child malaria deaths/1000		0.18
Child deaths/yr		42
PV earnings at 1yr	$2,706	
Cost of child death		$113,899
Malaria attacks/child	0.17	39,402
%Mild attacks	92%	36,250
%Severe attacks	8%	3,152
Adult time cost mild attack	$1.21	$43,927
Adult time cost severe attack	$1.82	$5,730
Treatment cost mild attack	$0.06	$2,355
Treatment cost severe attack	$38.98	$122,859
Cost of child illness	$174,870	
Adult population		271,546
Malaria attacks/adult	0.01	3,204
%Mild attacks	92%	2,948
%Severe attacks	8%	256
Time cost mild attack	$9.20	$27,129
Time cost severe attack	$15.78	$46,508
Treatment cost mild attack	$0.40	$1,181
Treatment cost severe attack	$38.98	$9,991
Cost of adult illness		$84,809
Total cost of malaria		$373,578

Assumptions:
1. Adult time loss 2 days for mild child illness
2. Adult time loss for child illness is female
3. Adult time loss is 3 days for severe child illness
4. Adult time loss for mild illness is 3.5 days
5. Adult time loss for severe illness is 6 days
6. Hospital costs were $6 per day in 1984
7. No good data on adult deaths, assume none
8. Severe attacks are 8% of cases

Table A.4.3 Economic Impact of Malaria in Brazzaville, 1984

Economic Impact of Malaria in Brazzaville, 1984
($US 1987)

Population	500,761
Cases	42,606
Direct cost	$136,385
Indirect cost	$237,192
Total cost	$373,578
Cost/capita	
Direct	$0.27
Indirect	$0.47
TOTAL	$0.75
Cost/case	
Direct	$3.20
Indirect	$5.57
Total	$8.77
Daily output/capita	$1.43
Daily cash income/capita	$1.04

Table A.4.4 Production in Brazzaville, 1995

Brazzaville 1995
Projected Income and Production
($US 1987)

	Males>15	Females>15	Total
Population	222670	222670	445340
%Active	74.3%	21.8%	48.1%
#Active	165444	48542	213986
Total daily production			$1,355,402
Marginal output/adult/year	$1,982	$258	$1,111
PV factor			2.82
PV earnings at 1yr			$3,133
Conversion factor 1984(CFA Francs per $US)			436.96
Conversion factor 1987(CFA Francs per $US)			300.54
Domestic price deflator(1987/84)			0.745
Urban growth rate of urban population			4.6%
Annual growth rate of industrial GDP			6.0%
Annual growth rate of malaria incidence			7.3%

Assumptions:

1. Production growth applied to 1984 total output
2. Female output 1995 at same ratio to male as 1984
3. Population growth rate applies equally to male and female
4. Population growth rate applies to adults
5. Output is equal for 365 days

Table A.4.5 Brazzaville: Direct and Indirect Costs of Malaria, 1995
Brazzaville Projected Direct and Indirect Costs of Malaria, 1995
($US 1987)

	Unit	Total
Total population		821,257
Child population		375,917
Child malaria deaths/1000		0.40
Child deaths/yr		150
PV earnings at 1yr		$3,133
Cost of child death		**$469,331**
Malaria attack/child	0.37	140,270
%Mild attacks	92%	129,048
%Severe attacks	8%	11,222
Adult time cost mild attack	$1.41	$182,163
Adult time cost severe attack	$2.12	$23,760
Treatment cost mild attack	$0.13	$16,766
Treatment cost severe attack	$58.46	$656,058
Cost of child illness		**$878,747**
Adult population		445,340
Malaria attacks/adult	0.03	11,407
%Mild attacks	92%	10,494
%Severe attacks	8%	913
Time cost mild attack	$10.65	$111,790
Time cost severe attack	$13.26	$191,640
Treatment cost mild attack	$0.80	$8,408
Treatment cost severe attack	$58.46	$53,352
Cost of adult illness		**$365,190**
Adult deaths		17
PV earnings at 35 years		$13,220
Cost of adult mortality		$220,057
Total cost of malaria		**$1,933,324**

Assumptions:

1. Adult time loss 2 days for mild child illness
2. Adult time loss for child illness is female
3. Adult time loss is 3 days for severe child illness
4. Adult time loss for mild illness is 3.5 days
5. Adult time loss for severe illness is 6 days
6. Hospital costs were $6 per day in 1984
7. No good data on adult deaths, assume none
8. Annual urban population growth 4.6%
9. Drug costs are 50% of hospital costs
10. Drug costs will double due to chloroquine resistance
11. Annual increase in rate of cases 7.3%
12. Severe attacks are 8% of total cases

Table A.4.6 Economic Impact of Malaria in Brazzaville, 1995

Projected Economic Impact of Malaria in Brazzaville, 1995 ($US 1987)

Population projection	821,257
Cases	151,677
Direct cost	$734,584
Indirect cost	$1,198,741
Total cost	$1,933,324
Cost/capita	
Direct	$0.89
Indirect	$1.46
Total	$2.35
Cost/case	
Direct	$4.84
Indirect	$7.90
Total	$12.75
Daily output/capita	$1.65
Daily cash income/capita	$1.20

Annex A.5 Economic Projections

Table A.5.1 Projections of Economic Growth Rates

Total GDP

	1980-87	1973-80	1965-73
Burkina	5.6%	3.9%	--
Congo	5.5%	4.7%	7.0%
Rwanda	2.4%	5.7%	6.4%
Chad	5.1%	-1.5%	0.4%

%I&S Industrial and Services Sector

	1987	1980-87	1973-80	1965-73
Burkina	62%	5.3%	5.5%	--
Congo	88%	6.0%	5.1%	7.4%
Rwanda	63%	3.2%	3.9%	--
Chad	57%	7.0%	-3.0%	--

%Agri Agricultural Sector

	1987	1980-87	1973-80	1965-73
Burkina	38%	6.1%	1.3%	--
Congo	12%	1.5%	2.1%	4.1%
Rwanda	37%	1.1%	8.7%	--
Chad	43%	2.6%	0.5%	--

Data calculated from World Bank 1989a

Annex A.6 Economic Impact of Malaria in Sub-Sahara Africa

Table A.6.1 Economic Impact of Malaria in Sub-Saharan Africa, 1987

Estimating the Cost of Malaria in Sub-Saharan Africa (Costs in 1987 $US, Estimated Incidence in 1987)

Case site	Direct cost/ case	Indirect cost/case	Total cost/ case
Rwanda	$2.19	$3.42	$5.60
Solenzo	$8.01	$3.52	$11.53
Brazzaville	$3.20	$5.57	$8.77
Mayo-Kebbi	$0.20	$12.60	$12.80
Mean/case	$3.40	$6.28	$9.68
	Direct cost/ capita	**Indirect cost/capita**	**Total cost/ capita**
Rwanda	$0.53	$0.83	$1.35
Solenzo	$1.65	$0.72	$2.37
Brazzaville	$0.27	$0.47	$0.75
Mayo-Kebbi	$0.01	$0.59	$0.60
Mean/capita	$0.62	$0.65	$1.27
Total Population 1987		451,000,000	
Population at risk		396,880,000 (88% at risk)	
Incidence/1000		202.6	
Estimated cases		80,407,888	
	Direct	**Indirect**	**Total**
Malaria cost	$273,386,819	$504,760,517	$777,946,316
Cost/capita	$0.61	$1.12	$1.72
GDP/capita	$298		
GDP/capita/day	$0.82		
GDP(millions)	$134,483		

Table A.6.2 Economic Impact of Malaria in Sub-Saharan Africa, 1995

Estimating the Cost of Malaria in Sub-Saharan Africa (Costs in 1987 $US, Estimated Incidence in 1995)

Case site	Direct cost case	Indirect cost/case	Total cost/ case
Rwanda	$3.31	$3.42	$6.73
Solenzo	$14.10	$6.68	$20.77
Brazzaville	$4.84	$7.90	$12.75
Mayo-Kebbi	$0.40	$30.30	$30.69
Mean/case	$5.66	$12.08	$17.74
	Direct cost/ capita	**Indirect cost/capita**	**Total cost/ capita**
Rwanda	$1.74	$1.79	$3.53
Solenzo	$5.98	$2.83	$8.81
Brazzaville	$0.89	$1.46	$2.35
Mayo-Kebbi	$0.04	$3.12	$3.16
Mean/capita	$2.16	$2.30	$4.46
Total population	575,765,799		
Population at risk	506,673,903	(Assumes 3.1% annual growth)	
Incidence/1000	202.6		
Estimated cases	102,652,133		
	Direct	Indirect	Total
Malaria cost	$581,267,702	$1,239,524,504	$1,820,535,576
Cost/capita	$1.01	$2.15	$3.16
GDP/capita	$280		
GDP/capita/day	$0.77		
GDP(millions)	$161,314	(Assumes 2.3% annual growth)	

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